TEXTBOOKS

Prepared by the Training Section

U. S. Office of Civilian Defense

See D. MacIntosh's suggestions
re decontamination stations p 25
(mobile stations stations
attached to troops only)

FIRST AID

in the Prevention and Treatment of

CHEMICAL CASUALTIES

MEDICAL DIVISION
OFFICE OF CIVILIAN DEFENSE
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PREFACE

This booklet is intended for the personnel of Emergency Medical Field Units and others who may be immediately concerned in the decontamination of persons and the administration of first aid to chemical casualties. Identification, characteristics, and tactical uses of the various agents are discussed only briefly; the reader is referred to the Civilian Defense textbook, "Protection Against Gas," for a more extensive discussion of these matters. For information on medical care and treatment consult Technical Manual 8–285, "Treatment of Casualties from Chemical Agents," prepared by the War Department and published by the Government Printing Office.

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FIRST AID
in the Prevention and Treatment of
CHEMICAL CASUALTIES

CHAPTER I—GENERAL CONSIDERATIONS

There is always a possibility in modern warfare that chemical agents may be used against unprotected civilian populations. Information on prevention and treatment of casualties from these agents should be disseminated widely, therefore, so that the population may be properly protected. Some of the agents with the most unpleasant and severe immediate effects do not cause permanent injury; proper precautions will prevent casualties from the more insidious and dangerous agents. Speed in applying protective measures is important; treatment immediately after exposure is more beneficial than anything that can be done later, after signs of injury appear.

A. Kinds

Chemical warfare agents are classified according to their effects. Substances of widely different chemical composition may fall in the same group because their action on the human body is similar:

1. Lung Irritants
2. Blister Gases
3. Tear Gases
4. Irritant Smokes (Sneeze Gases)
5. Incendiaries
6. Screening Smokes
7. Systemic (Internal) Poisons

B. Recognition

For his own protection, every individual should learn to recognize the odors of chemical agents. The trained individual must recognize them in order also to protect a disabled person in his care. "Sniff Sets" have been prepared

by the Chemical Warfare Service for use in familiarizing students with the various odors. Care must be taken in unstoppering sample bottles; heat may cause pressure enough to blow the cork out and spatter the agent.

1. Basic Rules for Identification by Odor

a. Do not smoke while sniffing. Smoking dulls the sense of smell.

b. Do not inhale deeply; sniff.

c. Sniff only once. Repeated sniffing dulls the sense of smell.

d. After each test, breathe out strongly through the nose several times. Do not sniff a new sample until the old perception has vanished.

e. First sniff; then think. The memory of odors can be trained by practice.

f. Learn odors by memory of the thing sniffed. A thing is odorless only when no perception of odor is obtained. Every perception of odor must be named.

g. Remember that in the field more than one agent may be present; the enemy may mix agents to produce confusion.

2. Table of Odors and Effects

	CHEMICAL WARFARE SYMBOL	ODOR	OTHER IMMEDIATE EFFECTS
Lung Irritants			
Phosgene	CG	Silage; fresh-cut hay	Coughing; tightness in chest; eye irritation.
Chlorpicrin	PS	Sweetish; flypaper	Tears; nose and throat irritation; vomiting.
Chlorine	CL	Disagreeable; like bleaching powder	Choking; coughing; pain in chest; smarting eyes.
Nitric fumes	——	Pungent	Coughing; brown stain.
Blister Gases			
Mustard	HS	Garlic; horseradish	None.
Lewisite	M–1	Geraniums	Smarting skin; burning eyes.
Ethyldichlorarsine	ED	Biting	Nasal irritation.
Tear Gases			
Chloracetophenone (also solution)	CN	Locust or apple blossoms; fruity	Flow of tears; irritation of skin.
CNB solution		Tire patching cement	Flow of tears.
Brombenzylcyanide	CA	Sour fruit	Flow of tears; nasal irritation.

Name	Chemical Warfare Symbol	Odor	Other Immediate Effects
Irritant Smokes (Sneeze Gases)			
Adamsite	DM	None	Headache; vomiting.
Diphenylchlorarsine	DA	None	Sneezing; vomiting; headache.
Incendiaries			
White phosphorus (also used as screening smoke)	WP	Matches	Burns; glow from particles.
Screening Smokes			
HC mixture	HC	Acrid	Slight suffocating feeling.
Sulfur trioxide in chlorsulfonic acid.	FS	Acrid (strong)	Prickly sensation on skin; eye irritation.
Titanium tetrachloride	FM	Acrid (mild)	Slight eye irritation.
Systemic (Internal) Poisons			
Hydrocyanic acid	——	Bitter almonds	Headache; dizziness; collapse.
Arsine	——	Garlic; metallic taste	None.
Hydrogen sulfide	——	Rotten eggs	Headache; dizziness; collapse.
Carbon monoxide	——	None	Headache; collapse.

C. General Protective Measures

The Army gas mask is the best individual protection against chemical warfare agents. *It will not, however, protect against carbon monoxide, ammonia, or oxygen-deficient atmospheres* and is, therefore, not suitable for use in fighting fires or in industrial accidents where ammonia fumes are present. It is important to learn by practice how to put on and adjust the mask quickly.

The amount of agent in the air (the concentration) determines the intensity and rapidity of the effects produced. The higher the concentration, the shorter is the period of exposure required to produce a casualty.

Get out of the contaminated atmosphere or area as soon as possible. Gases tend to travel downwind. If gas has been released in your immediate vicinity by bomb explosion or spray, move upwind. If gas has been released up-

wind from you, move across the wind till you are out of the stream.

Most agents are heavier than air and tend to settle in hollows. Therefore, avoid low places or basements. The second story of a building is practically safe. Close doors and windows, stuffing cracks and chimneys; this will keep gas out for hours. If windows are blown out by explosions, hang wet blankets over openings to keep gas from blowing in. The blankets should be fastened tight at the edges.

CHAPTER II—LUNG IRRITANTS

Phosgene (CG)
Chlorpicrin (PS)
Chlorine (CL)
(Nitric fumes)

All chemical warfare agents may act as lung irritants under certain circumstances, but with phosgene, chlorpicrin, chlorine, and nitric fumes, lung irritation is the most conspicuous effect. Nitric fumes have not been used directly in an attack, but are one of the gaseous products of nitrate explosives. Rescue Squad workers and others required to enter poorly ventilated buildings or tunnels following explosions may be exposed to dangerous concentrations of nitric fumes.

A. Latent Period

There is usually a latent period of 1 to 12 or more hours between exposure to lung-irritant gases and development of symptoms. Cigarette smoke is unpleasant during this period, but there may be no other indication that an individual has been gassed. This latent period always occurs after exposure to phosgene and may be longer than 12 hours; after exposure to chlorine, there may be none. After chlorpicrin, the latent period is short and may be less than an hour; after nitric fumes, it is long like that of phosgene. Chlorpicrin may cause eye irritation and vomiting in addition to lung irritation.

Persons exposed to lung irritants must be kept quiet during the latent period when they feel perfectly well. Any activity may cause sudden collapse and death. Patients must lie quietly and not attempt to feed themselves or even sit up.

B. Effects

Lung irritants cause pulmonary edema, a water-logged condition of the lungs which may cause the victim literally to drown in his own body fluids which pour into the irritated lungs. It is difficult for the heart to force blood through the damaged lungs, and death may result from circulatory collapse (heart failure) if the patient does not "drown."

C. Symptoms

There may be none for 12 to 24 hours after exposure, except that cigarette smoke is unpleasant. Examination of the chest by a physician reveals nothing abnormal. The patient then begins to breathe rapidly, becomes flushed and then bluish, and may develop a painful cough with swelling of neck veins (Blue Stage—Figure C). He may cough up blood-tinged frothy sputum and appear to be strangling. He may develop circulatory failure and turn a greyish leaden color, become cold and clammy, as in shock (Grey Stage). After recovery from this, he is still in danger of developing bronchopneumonia.

D. First Aid

1. Remove from the gaseous atmosphere and keep patient absolutely quiet in bed or on a stretcher. He must under no circumstances walk or even sit up, even though he may feel perfectly well. Keep him warm with blankets and hot drinks, and get him to a doctor as soon as possible. He must not smoke; it may cause coughing, which is an additional strain on the heart.

2. Do not give artificial respiration to relieve difficult breathing in the blue or grey stages. The lungs are full of fluid and any additional manipulation may be fatal.

3. If symptoms appear, the patient should be given oxygen to breathe if available.

CHAPTER III—BLISTER GASES

Mustard (HS)
Lewisite (M–1)
Ethyldichlorarsine (ED)

Because of their ability to render an area unhabitable for days, the blister gases are among the most important and effective chemical warfare agents. They are more liable to be used against a strategic civilian area than the lung irritants, which are quickly dissipated.

The blister agents are not true gases but are oily volatile liquids. They may be used as a bomb filling or may be discharged from an airplane as a fine spray which behaves as a gas. The liquid slowly vaporizes into a true gas. Both vapor and spray are heavier than air and tend to drift into and linger in cellars, ditches, and other low places.

Both liquid and vapor irritate, burn, and blister any skin or mucous membrane with which they come in contact. Because of their persistence and insidiousness, blister agents cause many casualties, but the death rates are low. Only 2 percent of blister-agent casualties in the First World War were fatal.

A. Special Characteristics

1. Persistence

Under normal weather conditions in temperate climates, they may persist for days in an area sheltered from wind and sunlight. In winter they persist longer.

2. Power

The power of these agents is so great that a drop the size of a pin head can produce a blister the size of a quarter (Figure A, B). Exposure for 1 hour to air containing 1 part per million of vapor can cause a casualty. The eyes are particularly susceptible.

3. Penetration of Materials and of the Human Body

The blister agents "soak in" as ink soaks into a blotter. This is not the same as "eating in" of an acid; the penetration takes place without damage to clothing. Because the

agents are highly soluble in fats, they also readily soak into the body. A drop of mustard on the skin glistens for about 2 minutes and then is absorbed. Only metals, glass, highly glazed tiles and porcelains, and specially-treated fabrics resist their penetration. The agents penetrate rubber.

4. Insidiousness

Even in concentrations sufficient to cause burns, the presence of these agents, particularly mustard, may not be detected by odor or by any immediate irritation.

5. Delayed Action

Their ability to cause damage before any evidence of their presence is recognizable makes these agents dangerous. A patient may be sufficiently contaminated to cause extensive burns and show no signs of injury for 12 or more hours.

6. Universal Action

These agents burn and blister any tissue, on the surface or in the interior of the body, with which they come in contact. Their effects are not limited largely to one set of body structures as is the case with tear gases and lung irritants. Although the skin is most apt to be exposed, the lungs may be injured by breathing vapor and the stomach by swallowing contaminated food, water, or even saliva.

There are two types of blister agents:

1. Those which cause only local surface irritation.
2. Those which also cause systemic (internal) poisoning. These usually contain arsenic.

More than any other type of chemical agent, the blister gases, especially those containing arsenic, will poison food and water, and render other supplies dangerous to handle until they have been decontaminated.

Before transporting or treating blister-agent casualties, medical unit personnel must apply to themselves those individual or collective measures which are necessary for their own protection, or they will also become casualties. A gas mask protects only the face, eyes, and lungs; protective ointment must be used on exposed parts and protective clothing worn where possible.

Table of Differences Between Lewisite and Mustard

It is important to distinguish between mustard and lewisite burns because of the greater severity and danger of arsenic poisoning from lewisite.

	MUSTARD	LEWISITE
Odor*		
	Very slight odor; like garlic or horseradish.	Definite odor; like geraniums.
Persistence in Contaminated Area		
Summer	4 or 5 days in open; 1 week in woods.	24 hours in open; 2 or 3 days in woods.
Winter	Several weeks.	One week or more.
(At low temperatures lewisite is more volatile than mustard and is therefore more dangerous in cold weather.)		
Immediate Effects		
On skin	None, even from liquid.	Sharp tingling from liquid.
Nose	None.	Breathing vapor for a few minutes causes sharp burning irritation.
Eyes	None from vapor. Mild irritation from liquid.	Immediate severe pain from liquid.
Skin Burns		
	Much itching; little pain. Blisters filled with clear fluid and surrounded by an area of erythema (redness).	Painful as well as itching; blisters filled with cloudy fluid. No surrounding erythema (redness).
Late Effects		
Skin	Burns only skin.	Burns through skin into muscles.
Eyes	Severe inflammation but rarely scarring with loss of vision.	Inflammation more severe and usually causes some scarring and permanent impairment of vision.
Entire body	Produces no systemic (internal) poisoning.	Produces systemic poisoning with arsenic.

*Prolonged exposure to either mustard or lewisite in concentrations barely detectable by odor will cause casualties.

The effects of this group of chemicals vary with the portion of the body exposed. Signs and symptoms may be delayed, particularly with mustard. The length of the latent period depends on the concentration of the agent and on the individual sensitivity of the skin. *Prolonged exposure to concentrations barely detectable by odor will produce casualties.*

B. Mustard

1. Effects

In persons unprotected by masks, eye symptoms are generally the first to appear. These begin with smarting and watering of the eyes 2 or 3 hours after exposure to vapor, followed by reddening and swelling. There is considerable pain, especially from bright light, and swelling may completely close the lids. If liquid is splashed into the eyes, there is almost immediate burning and all symptoms develop more rapidly. Eye burns vary from simple irritation and redness following mild vapor to severe ulceration from liquid mustard.

Sneezing and running nose are also early symptoms.

Skin burns from vapor may not appear until 12 or more hours have elapsed, but may develop within 1 hour after contact with liquid mustard. The first symptom may be severe itching, followed by a sunburnlike redness, upon which small and large blisters develop. Shortly before the development of blisters, the surface of the reddened skin can be rubbed raw with slight pressure and friction. When liquid has been splashed on the skin, the blisters may be arranged in a ring around a central, whitish, indurated area. The blisters are surrounded by a zone of redness. Because of the depth of skin destruction, mustard burns may require some weeks to heal and may become infected.

Vapor burns are more severe on areas of the body covered by clothing, which interferes with the dissipation of the mustard, and also on those areas subject to friction where the skin is moist or thin. The elbow, knee, and neck folds, external genitalia, and armpits are particularly susceptible. The fluid contents of mustard blisters are not irritating to the skin.

Irritation of the lungs is first indicated by hoarseness followed by a harsh brassy cough, later followed by production of yellowish sputum. These cases are serious

because bronchopneumonia may develop. This condition was responsible for most of the deaths from mustard gas during the First World War.

Stomach irritation with nausea and vomiting may result from swallowing contaminated food, water, or even saliva.

Figures A, B, D, E, and F illustrate various stages and types of mustard burns. Figure A shows a blister 48 hours after contamination with liquid mustard and B the same area after two weeks. Figure D shows the appearance of an individual burned by vapor. Note the red eyes and the sunburn-like blush of the areas covered by clothing, particularly the skin folds. Figure E shows the desquamation (peeling) two weeks after a vapor burn on the body. Figure F shows the healing appearance five weeks after liquid mustard was spilled on the foot.

2. *Prevention—First Aid*

To be effective, treatment must begin within a few minutes after exposure. *Immediate prophylaxis is effective only up to 5 minutes after liquid contamination.* It is of little value after exposure to vapor because in this form most of the agent has penetrated the skin before the person reports for treatment.

Contaminated clothing must be removed quickly, using proper precautions (mask, gasproof gloves, apron, protective ointment) to protect the attendant. Clothes must be placed in a covered metal container until decontaminated. (Figure G.)

Great care must be used in the removal of mustard from the skin; otherwise the agent will merely be spread. The steps are as follows:

a. Gently apply dry pads to absorb any mustard remaining on the skin.

b. Gently and repeatedly dab the area with sponges dampened with gasoline (nonleaded), kerosene, carbon tetrachloride, or alcohol. These solvents, except carbon tetrachloride, are inflammable; keep away from open flame. Have sponges only damp with solvent; if dripping wet, the agent may be dissolved and spread over the skin.

c. Scrub the skin surface within and beyond the margins of the contaminated area with soap and water.

d. Pat the area dry with a towel. *Do not rub.*

FIGURE A.—Blister following liquid mustard.

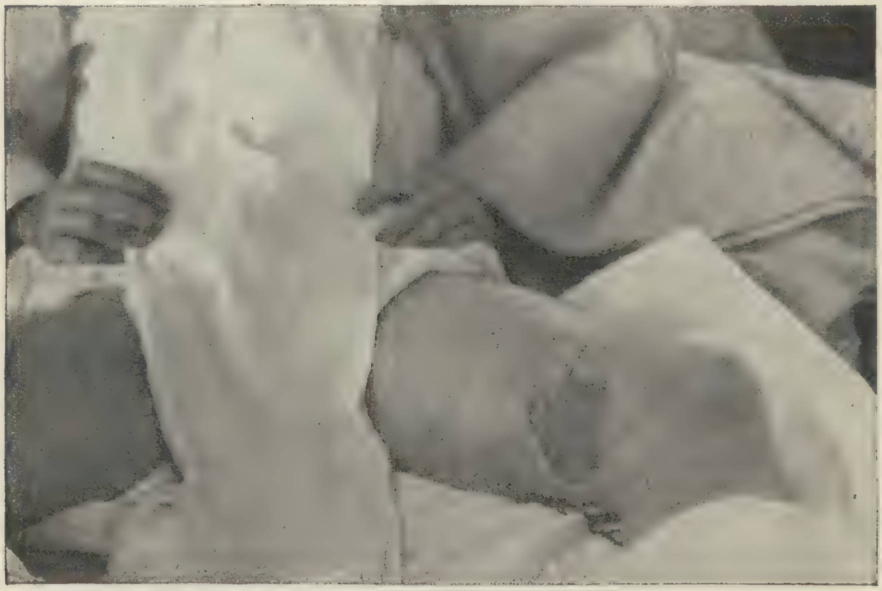

FIGURE B.—Same as figure A after two weeks.

e. Burn or bury the materials contaminated during the procedure. Keep away from the smoke while contaminated materials are burning; it may contain mustard vapor.

The protective ointment (Chemical Warfare Service) also effectively removes mustard from the skin surface if it is applied with rubbing and then wiped off. Products containing active chlorine, such as bleaching powder and commercial bleaching solutions, may also be used. Bleaching powder should be mixed with 1 or 2 parts of water. Dry bleaching powder may be used if water is not available, but the reaction with mustard will generate heat. Even so, the effect will be less than if mustard were left on the skin. Ordinary bleaching powder does not exceed 30 percent chlorine; high-test bleaching powder of 70 percent chlorine should never be used dry; reaction with mustard will cause burns.

Bleaching powder and solutions are irritating and must be removed from the skin as soon as possible (within a few minutes) or they will increase the burn. *Be sure to keep them out of the eyes.* If reddening of the skin indicates that the burn has already begun to develop, *do not use these compounds; they will only increase the irritation.* It is preferable to apply antipruritic ointment (Appendix, Item 10) to relieve the itching.

The eyes should be irrigated with a 2 percent solution of sodium bicarbonate (baking soda) unless they have been protected by a mask. The solution should be run directly into the eyes with a rubber tube from an enema can or similar container. Petrolatum on the edges of the eyelids will prevent their sticking together. A 2 percent solution of butyn may be instilled in the eyes to relieve pain. *Cocaine must not be used;* it may cause ulceration. *The eyes must not be bandaged.*

If it is likely that mustard has entered the mouth or nose, the mouth and nasal passages should be rinsed and the throat gargled repeatedly with 2 percent solution of sodium bicarbonate. The patient should be kept quiet and warm to guard against bronchitis and bronchopneumonia.

If nausea and vomiting indicate that contaminated materials have been swallowed, the stomach should be washed out by repeated drinking of warm 2 percent solution of sodium bicarbonate. This will induce vomiting and wash out the irritant.

After decontamination, all persons with eye, nose, and throat burns and with any but slight skin burns should be hospitalized. Skin burns must be treated surgically as any severe extensive burn.

C. Lewisite

Lewisite is similar to mustard in physical characteristics but is more volatile and hence more effective in cold weather. It is also more immediately irritating and is more dangerous because it contains arsenic. Water breaks it down into a solid oxide containing arsenic, which is also irritating and poisonous. This solid is extremely persistent; contact with ground which has been contaminated with lewisite will cause burns for a long time thereafter.

1. Early Effects

Symptoms develop earlier and are more severe than with mustard. Liquid lewisite in the eye causes immediate pain. On the skin, redness appears within 15 to 30 minutes after contamination with liquid, and blisters soon appear, reaching their maximum within 12 hours. The entire area blisters, leaving no red margin around the blister as is usually observed in mustard burns. *The blister fluid contains arsenic and is itself capable of causing burns and general poisoning.*

2. Late Effects

Lewisite burns are more painful and more dangerous than mustard burns. Lewisite in the eye may cause blindness. In addition to painful burns which may later become infected, symptoms of arsenic poisoning may appear. These are dryness and soreness of the throat, diarrhea, and restlessness. Later, paralysis of arm and leg muscles may develop.

Until neutralized or removed, lewisite continues to penetrate, burning through the skin into muscle or other body tissue. It differs in this respect from mustard, which never penetrates beneath the skin unless carried into a wound by contaminated shell or bomb fragments.

3. Prevention—First Aid

a. *Eyes.*

Liquid lewisite in the eyes is an emergency. The eyes must be treated immediately and repeatedly with instillation of 2 percent hydrogen peroxide. If this is not

FIGURE C.—Blue stage of phosgene poisoning

FIGURE D.—Mustard vapor burn of body and eyes

FIGURE E.—Mustard vapor burn of body after two weeks

FIGURE F.—Liquid mustard burn of foot after five weeks

available, they must be irrigated with a 2 percent solution of sodium bicarbonate. Delay may result in blindness.

b. *Skin.*

Treatment must begin within 1 minute after contamination with liquid lewisite to be really effective. Contaminated clothing must be quickly removed with precautions to protect the attendant, and treatment should be started while clothing is being removed. The contaminated areas should be swabbed immediately and repeatedly with hydrogen peroxide. Solutions with 10 or even 20 percent available oxygen are best, but are unstable. (These strong solutions must not be used in the eyes.) The ordinary 2 percent solution available in drugstores will suffice. If hydrogen peroxide is not available, a solution of 10 percent sodium hydroxide (lye) in a 30 percent solution of glycerin in water, alternating with 70 percent alcohol, is the second choice. The glycerin protects the skin from the lye. If no glycerin is available, 5 percent lye in water may be used. Lacking all these, the solvents and technique described for liquid mustard must be used. Following treatment, the skin should be washed with soap and water and patted dry. *All contaminated cloths or sponges must be burned or buried.*

It is extremely urgent that patients contaminated with lewisite come immediately under medical treatment. The doctor must open the blisters as soon as possible to prevent further absorption of arsenic. In opening the blisters, he must be careful to prevent infection and must remember that the blister fluid itself is capable of producing burns. If liquid lewisite has remained on the skin for any considerable length of time, surgical removal of the contaminated area may be necessary to reduce the risk from the arsenic which it contains.

D. Ethyldichlorarsine

This compound may also be employed as a blister agent. It is less persistent than lewisite or mustard, lasting from 1 hour in the open in the summer to 12 hours in the woods in the winter.

1. Immediate Effects

It is more irritating to nose and throat than lewisite or mustard. Immediate symptoms of sneezing and often

vomiting are therefore common. It is less irritating to the skin and therefore less apt to blister. It is capable, however, of causing arsenic poisoning.

2. First Aid

Immediate measures are the same as for lewisite. Nose irritation may be relieved by inhaling dilute chlorine from a small amount of bleaching powder in a wide-mouthed bottle or can. If vomiting is persistant, the stomach should be washed out by repeated drinking of warm 2 percent solution of sodium bicarbonate.

CHAPTER IV—TEAR GASES (LACRIMATORS)

Chloracetophenone (CN)
Chloracetophenone Solution (CNS)
CNB Solution (CNB)
Brombenzylcyanide (CA)

These are substances which produce severe but temporary eye irritation. Permanent damage rarely results. Many other chemical warfare agents also irritate the eyes but require greater concentrations than the tear gases. The tear gases, however, may cause panic in an uneducated population that does not understand their relative harmlessness and the rarity of serious after effects. Tear gases are not persistent, except brombenzylcyanide which is as persistent as mustard.

A. Effects

Exposure immediately produces spasm of the eyelids with sensitiveness to light, inability to open the eyes, copious tears, and some irritation of a freshly shaven face. Chloracetophenone solutions may cause a mild rash in warm weather and occasionally vomiting. If the solution itself gets into the eyes, there may be permanent damage.

B. First Aid

The individual should be removed from the contaminated air and face the wind with eyes open. If irritation is marked, the eyes may be irrigated with boric acid or a 2 percent solution of sodium bicarbonate (baking soda). *The eyes must not be rubbed or bandaged.*

Skin irritation may be treated by sponging with a solution of 4 percent sodium sulfite in 50 percent alcohol. All symptoms usually disappear within an hour.

CHAPTER V—THE IRRITANT SMOKES (SNEEZE GASES OR STERNUTATORS)

Adamsite (DM)

Diphenylchlorarsine (DA)

These agents are used to produce irritation of the nose, throat, and eyes, and are dispersed in clouds or smokes of very fine particles rather than as true gases. Their action is so delayed that symptoms may not appear until after the mask has been put on. When this occurs, an untrained person may think his mask unsatisfactory and remove it, becoming a casualty from further exposure. These agents are very insidious. They have no odor and are usually detected only when symptoms appear.

A. Effects

There is pain and a feeling of fullness in the nose and sinuses accompanied by violent sneezing and running of the nose. Severe headache may develop, followed by burning in the throat and tightness and pain in the chest. Nausea and vomiting may occur, and eye irritation may produce a flow of tears. A striking peculiarity of these agents is the mental depression they induce. Severely gassed persons may attempt suicide.

B. Diagnosis

This is based on the presence of the symptons just described, followed by relatively rapid recovery despite the miserable appearance and condition of the individual.

C. First Aid

Remove to pure air if possible. A nasal spray of pontocaine and neosynephrin gives relief. (See Appendix No. 12.) Inhalation of dilute chlorine from a small amount of bleaching powder in a wide-mouthed bottle or can is also effective. Headache may be controlled with 10 to 15 grains of acetylsalicylic acid (aspirin). There are no after effects and the individual recovers within a few hours.

Severely exposed individuals must be watched for suicidal tendencies. Continue to reassure them that their symptoms will be of brief duration and are not dangerous.

CHAPTER VI—INCENDIARIES

Thermit—Molten or Burning Metal
Oil
White Phosphorus

A. Thermit and Oil

Burns from molten metal are apt to be deep and severe due to the high temperature. Immediate first aid consists in flushing spattered globules of metal with large quantities of water to produce cooling. Flaming oil on clothing or skin must be smothered. Treatment is the same as for burns from any other cause.

B. White Phosphorus

This agent ignites by itself in the air. Water or wet cloths will quench the fire, but as soon as the particle dries in air, it again begins to burn. The effect of particles on the skin is the same as of any heat burn; they stick and burn until removed, or until air is excluded by covering with water or treating with copper sulphate (blue vitriol).

First Aid

Keep the burn wet with water or wet cloths until the particles can be squeezed or picked out. Warm water, about 40° centigrade (104° Fahrenheit), melts phosphorus and makes squeezing easier. If squeezing does not bring out the particles, they must be picked out with forceps. Do not use mud as formerly recommended; it may cause infection. Urine is sterile and is satisfactory if there is no other source of water.

Unless there is water and time for immediate treatment, apply a 5 to 15 percent solution of copper sulphate to the burn. This coats the phosphorus with copper phosphide, shuts out the air, and stops the burning until the particles can be removed.

After the phosphorus has been removed, further treatment is exactly the same as for any other heat burn.

CHAPTER VII—THE SCREENING SMOKES

HC Mixture (HC)
White Phosphorus (WP)
Titanium Tetrachloride (FM)
Sulfur Trioxide-chlorsulfonic Acid Solution (FS)

These are used to screen positions or troop movements or to mask gas-cloud attacks with other agents. They do no damage in ordinary field concentrations but may be dangerous in the heavy concentrations formed at the site of release. They are of practical concern, therefore, only to the military personnel, or to persons in the immediate vicinity of an exploding shell or bomb containing the agents.

A. White Phosphorus

The smoke from white phosphorus is harmless, but particles from a shell explosion will cause burns and should be treated as described under incendiaries.

B. Titanium Tetrachloride and Sulfur Trioxide Solutions

The liquids produce acid-like burns of the skin. They are irritating and unpleasant to breathe, but are not dangerous. Spray in the eyes may cause serious burns.

First Aid

This consists in washing with large quantities of water. In the eyes, this should be followed by irrigation with a 2 percent solution of sodium bicarbonate (baking soda). If severe, the patient must see a physician.

CHAPTER VIII—THE SYSTEMIC POISONS

Hydrocyanic Acid
Arsine
Hydrogen Sulfide
(Carbon Monoxide)

Although not immediately irritating to the skin, eyes, nose, or lungs, these agents cause systemic (internal) poisoning and, if inhaled in sufficient quantity, they may cause death. Hydrocyanic acid and hydrogen sulfide may be immediately fatal; arsine produces destruction of the red blood cells, which block the kidneys and may cause death in a few days. Carbon monoxide, while not used as a war gas, may be encountered following breaks in illuminating gas mains.

A. Hydrocyanic Acid and Hydrogen Sulfide

1. Immediate Effects

Odor of bitter almonds (hydrocyanic acid) or rotten eggs (hydrogen sulfide) may be noticed, but strong concentrations dull the sense of smell and the individual may be overpowered and collapse immediately. Weaker concentrations may produce headache, dizziness, and nausea.

2. First Aid

Anyone rendering first aid in a gassed area to an individual who has just collapsed must be protected by a mask or he will also collapse. *Do not enter a gassed area without a mask to bring anyone out; you will not get out yourself.*

First aid consists in inhalation of amyl nitrite fumes and artificial respiration, until a physician can begin medical treatment. Artificial respiration should be continued for hours, even though it appears hopeless.

B. Arsine

Odor of garlic and metallic taste are the only immediate effects. Persons exposed to arsine must be kept quiet, and hospitalized as soon as possible. Meanwhile, they should be given large quantities of alkalies such as sodium bicarbonate, citrate, or phosphate to drink. This alkalinizes the urine and may help to prevent coagulation in the kidneys of protein from the red blood cells destroyed by the arsine.

C. Carbon Monoxide

This is the colorless, odorless constituent of automobile exhaust and artificial illuminating gases which causes many fatalities. It replaces the oxygen in the blood and the victim is rapidly asphyxiated. It may be encountered in enclosures where fire has been burning with a limited air supply, in basements and tunnels where gas mains have been ruptured, and in other closed places.

1. Effects

With high concentrations, the victim collapses without warning after breathing the contaminated atmosphere for a few minutes. Lower concentrations first cause headache and dizziness followed by collapse.

2. First Aid

Immediate removal from the contaminated atmosphere is most important. If breathing is shallow or has stopped, artificial respiration must be instituted and continued until the patient is breathing normally again. This may require some hours.

As soon as it can be made available, the individual should be given oxygen to breathe. *Do not wait for oxygen before starting artificial respiration.*

CHAPTER IX—DECONTAMINATION STATIONS

Because of the persistent nature of blister gases, arrangements must be provided for their removal from clothing and skin at special "Decontamination Stations." Persons contaminated with these agents must not be brought to regular First Aid Posts or Casualty Stations.

Steps in Decontamination

Ambulatory contaminated individuals including stretcher bearers, presumably masked, walk through a box for the decontamination of shoes as they enter. This box is filled with bleaching powder and dirt mixed in the ratio of 1 scoop of bleach to 2 of dirt. This proportion is proper for the usual bleaching powder with 30 percent chlorine. If bleach with a different chlorine content is used, the proportions of bleach and earth should be adjusted accordingly. Inasmuch as contaminated materials are being brought into this room, an exhaust fan near the floor is provided, and masks and protective clothing are worn by the permanent attendants. Clothing is removed and deposited in covered metal cans, and an attendant is on duty for the undressing of stretcher cases. If the stretcher has been contaminated, the casualty must be shifted to a clean one. The individual then sponges himself or is sponged by the attendant with hydrogen peroxide, lye, kerosene, or alcohol, as described in the text. The contaminated sponging materials must also be deposited in covered metal containers.

The individual then goes through a gas lock and is bathed with soap and water. The gas lock must afford space for the admission of a stretcher with bearers. Again an attendant is on duty with a spray for bathing stretcher cases.

The individual then goes to the clean-clothes issue room where there is a physician in attendance for care of the wounded. Provision must be made there for irrigation of the eyes of contaminated individuals. The wounded may be evacuated from this room to the hospital by ambulance.

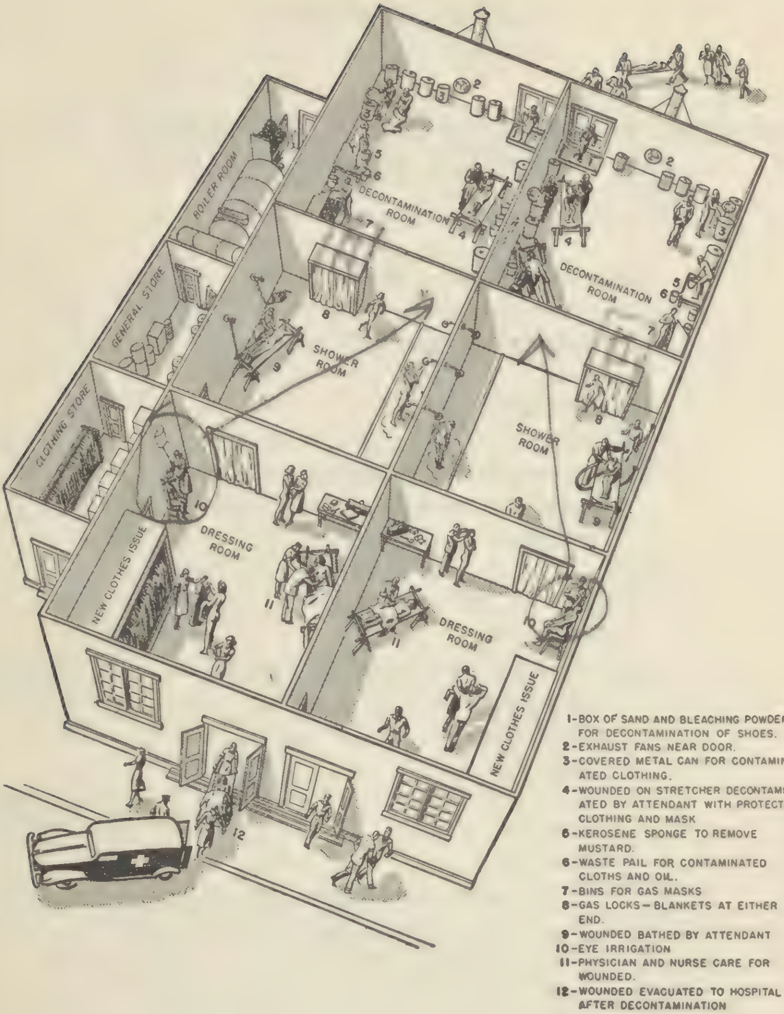

Figure G indicates the steps in the decontamination procedure and suggests a suitable arrangement of facilities. The essentials are plenty of covered metal containers for contaminated clothing and materials, a gas lock composed of a short tunnel, the ends of which are closed with blankets, to keep contamination from following the subject into the shower room, plenty of hot water, and a supply of clean clothing. Partitions separating the sexes can be arranged with sheets if space is limited. Although public buildings, such as schools, may be adapted, it is possible that temporary or even portable structures may be feasible for decontamination.

APPENDIX

Recommended Contents of Special First-Aid Chest for Gas Casualties

1.	Bleaching powder—30%	2 lbs.
2.	Protective ointment—3-oz. tube	10
3.	Hydrogen peroxide—10% available oxygen.	1 qt.
4.	Kerosene	6 qts.
5.	Alcohol—70%	1 qt.
6.	Soap	6 cakes
7.	Sodium bicarbonate (baking soda) . . . . (Two teaspoonsful per pint make 2% solution)	5 lbs.
8.	Lye	1 lb.
9.	Butyn N. N. R. 3 gr. hypo. tablets, 10 tablets per vial	2
10.	Antipruritic ointment for mustard burns . .	3 ounces
	Benzyl alcohol 50%	
	Stearic acid 30%	
	Glycerin 10%	
	Ethyl alcohol 8%	
	Pontocaine 1%	
	Menthol 1%	
11.	4% solution sodium sulfite in 50% alcohol .	8 ounces
12.	Neosynephrine hydrochloride 1% 4 Pontocaine hydrochloride . . . . . 04 . Boric acid saturated solution . . 12	2 ounces
13.	Acetylsalicylic acid (aspirin) 5-gr. tablets .	100
14.	Cupric sulfate (blue vitriol)	1 lb.
15.	Amyl nitrite U. S. P. Ampules—5 min . .	2 doz.
16.	Absorbent cotton	1 lb.
17.	Enema can and tube for irrigating eyes . .	1

Uses of Above Agents

1. For decontamination of skin from blister agents; for inhalation following irritant smokes.
2. For protection of skin and decontamination following blister agents.

3. For removing lewisite from skin.
4. For removing mustard from skin.
5. Following Nos. 4 and 8.
6. To remove Nos. 3, 4, and 8.
7. *a*. For eye irrigation following blister gases, tear gas, or other chemical agents.
   b. For washing nose, throat, and stomach following blister agents.
   c. For drinking after arsine exposure.
8. For lewisite if Nos. 1 and 3 not available.
9. For preparing solution to relieve pain in eyes from mustard and lewisite.
10. To relieve itching following mustard burns.
11. For removing tear gases from skin.
12. For nose spray following irritant smokes.
13. For headache following irritant smokes.
14. For phosphorus burns.
15. For hydrocyanic acid poisoning.

SUBJECT INDEX

FIRE PROTECTION IN CIVILIAN DEFENSE

U. S. OFFICE OF CIVILIAN DEFENSE

Washington, D. C.

Prepared by the War Department

With the Assistance

and Advice of Other Federal Agencies

Approved by the Advisory Committee
on Civilian Fire Defense

Issued by the OFFICE OF CIVILIAN DEFENSE
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Prepared under the direction of the Quartermaster General with the cooperation of the Office of Chief of Chemical Warfare Service and suggestions of the National Technological Civil-Protection Committee

INDEX

Fire Protection

FOREWORD

Hundreds of thousands of incendiary bombs, each capable of starting its own blaze and potential conflagration, were dropped in an 8-hour air raid upon London in April 1941. In the average well-built city only about 15 percent of the area is occupied by buildings—the balance consisting of roads, parks, lawns, and unoccupied lots; while a varying percentage of the buildings are themselves fire-resistant. Assuming a uniform pattern and no duplication of coverage, only about one out of six or seven incendiary bombs will land on a roof or anything else that will burn. Even at that, each thousand bombs will start about 166 fires—and, therefore, potential conflagrations. Over 2,000 fires were started in London in that raid.

But from 650–700 planes, each carrying a normal load of one thousand 2½ pound incendiary bombs, or their equivalent in weight, were required. Even one bomber proceeding at 200 miles an hour and dropping the usual 50 bombs a second can light a fire about every 15 yards—so that even a moderate-sized house might very well have two fires set by incendiary bombs from the same bombing plane. Incendiary bombs are frequently dropped in containers which explode and scatter the bombs from a low altitude. A building within the area over which such a container bursts may receive several hits.

In spite of the fact that many more incendiary bombs were dropped in the raid in April 1941 than in the December 1940 raid, far less damage resulted from the April raid because the London fire defense was prepared to meet the situation.

This booklet describes a plan for the average American community, based on the only practicable means thus far proved effective for overcoming this menace; that is, continuous observation during attack and prompt extinguishing of bombs and incipient fires by those most concerned—the individuals who live or work in the structures menaced.

Chapter I.

INTRODUCTION

1. *General.*—Fires result from the general use of materials and processes involving fire and flammable or explosive substances. In organized communities, fire defenses are maintained at public expense or by volunteer services. Such defenses, comprising fire departments, water supplies, and water-distribution systems, fire-alarm services and fire-prevention activities, vary widely as to extent and effectiveness.

The program for defense contemplates a regular local fire-fighting organization that is organized and equipped to afford protection against the normal fire hazard of the community. Emergency or auxiliary forces must be organized, equipped, and trained, and all able-bodied persons instructed in fire-fighting methods to meet the added fire-defense problem of enemy attack.

2. *The Normal Fire Fighting Organizations* are the regularly organized fire departments, full paid or volunteer, and the private fire brigades maintained in industrial plants, warehouse areas, business establishments, or institutions.

3. *Auxiliary Reserve Forces* consist of trained personnel organized and equipped to augment the regular fire-fighting forces in the event of an emergency. These reserves are organized as separate fire companies or as sections, attached to regular companies. The auxiliary forces have definite assignments with the regular fire department during periods of emergency.

4. *Neighborhood Fire Watcher Plan.*—Groups of citizens organized under District Fire Watchers constitute the first line of defense against incendiary aerial bomb attacks. It is only through the prompt detection and extinguishment of such fires that major fires can be prevented. Through the proper functioning of the Fire Watcher groups, the regular and auxiliary fire forces may concentrate on the fires of serious consequence.

5. *Fire Watch Service.* —In addition to the lookouts posted on high buildings or other elevations to observe the approach and movement of the enemy, time, place, and nature of occurrences, there should be an organization of civilians throughout all sections of the community to observe and report on fires as they occur. The location of these fire-watch service posts vary according to the type of buildings in the area, the topography and the communication facilities available. These Fire Watchers report directly to the Sector Warden's office the location of fires, their magnitude, and the apparent relative threat of each fire, considering the weather conditions and direction of wind at the same time. Their duties also include an immediate attack upon fallen incendiaries, to control them before a blaze is started.

Place watchers on high places, standpipes, steeples, etc., so that all roof areas can be watched with the fewest posts.

Chapter II.

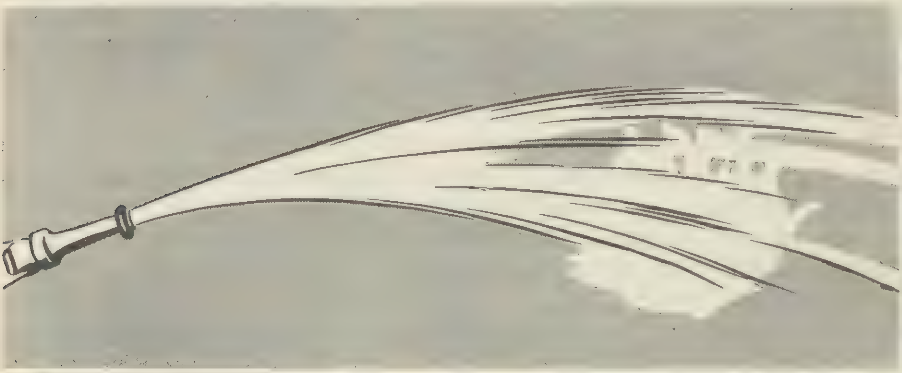
INCENDIARY BOMBS

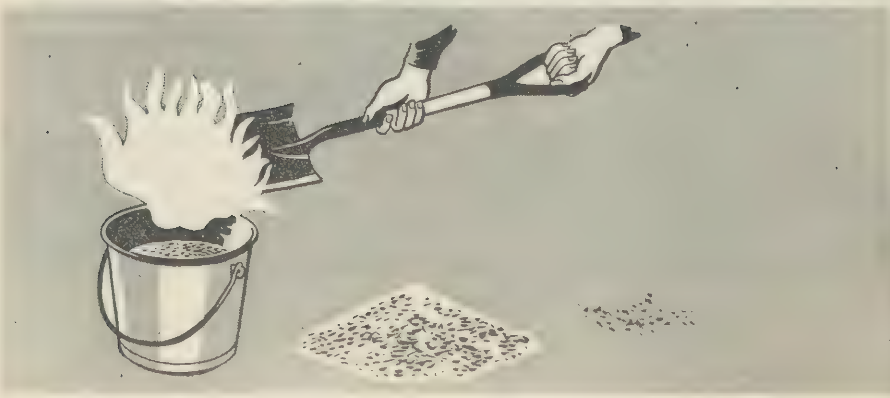
SECTION I.—GENERAL CONSIDERATIONS

6. General.—Substances which, on burning, generate tremendous heat and thus readily set fire to other combustible material with which they come in contact are referred to as *incendiary materials* or *incendiaries*. The use of incendiary substances to cause destruction of buildings, crops, food, ammunition supplies, or other combustible material of military importance has been resorted to in practically all wars. In modern warfare, incendiary materials are dropped from aircraft in bombs and are employed by ground troops in artillery or mortar shells, grenades, and flame-throwers. In the usual case where a town or city is attacked by ground forces, it is evacuated beforehand by the civilian population. Thus, a civilian's fire-fighting problems, due to warfare, are principally those resulting from hostile air attacks. At any rate, the procedure as described herein for dealing with incendiary bombs would apply also to incendiary grenades or shells.

7. Incendiary Bomb Problems.—Air attacks upon a town or city may be made with high explosive or incendiary bombs, or both. High explosive bombs dropped upon any built-up area are frequently followed by fires. Upon its explosion, a high explosive bomb is immediately destroyed, but any resulting fire must be attacked in the customary manner. In the case of an incendiary bomb, however, the incendiary material of which it is composed is not immediately consumed after the bomb is ignited. This material continues to burn for a period of one to twenty minutes, or even longer, the time depending upon the size and composition of the bomb. So intense is the heat generated that unless a bomb which has penetrated a building is promptly extinguished or removed it may quickly burn through one floor and drop to the floor below, thereby spreading the fire. Hence, it frequently is of first importance to deal with the bomb itself, leaving the burning area about it to be attended to later. However, the proper procedure for dealing directly with an incendiary bomb is somewhat different from that which applies generally in fire fighting. This procedure varies according to the particular kind of bomb encountered. For example, the usually proper course of deluging a dangerous blaze with water might be a serious mistake in dealing with certain kinds of incendiary bombs. As will be seen later

herein, water in these cases is effective and should be used, but only in a certain way. Indiscriminate dousing of water on a burning magnesium alloy bomb would in all probability produce an explosion, thus needlessly endangering the fire-fighter and spreading the fire. On the other hand, if the bomb is a phosphorous bomb, a liberal use of water, in the absence of certain special means, is clearly indicated. From this brief discussion it should be evident that to cope intelligently with incendiary bombs one must know something about them. He must know how to identify the different types and understand the specific methods of fire fighting indicated in each case.





8. Fire Department Limitations.—A citizen may ask why he need concern himself with these matters when there is a fire department available and maintained at the public expense to provide proper fire protection. The answer is that no fire department system, even though greatly augmented with auxiliary services, can be expected to deal with the multitude of fires which may result from an air attack in which incendiary bombs are used. A modern bombing airplane can carry from 1,000 to 2,000 small incendiary bombs, any one of which, dropped from a considerable altitude, is capable of penetrating an ordinary house roof whether of tile, slate, shingles, or composition material. Such small bombs, which generally weigh about 2 pounds, are not designed for any high degree of accuracy in their use. They are employed in large numbers and when dropped they are scattered over a considerable area. Even though a single building is the target aimed at, many other buildings in the same area may be hit. In a closely built-up city, based upon calculations as to the average proportion of the built-over area to open space, it is estimated that one out of every six bombs dropped is likely to strike and penetrate a building. On this basis, a single airplane releasing 1,000 such bombs on the city might be expected to cause 166 different fires. In attacks on cities, however, many airplanes, hundreds perhaps, will be employed. Obviously, then, it would be impracticable for the city fire department to deal with all the fires thus caused.

9. Responsibility of Householder.—In areas subject to air attack the responsibility of providing for his own fire protection in time of war, especially in case his house is struck by an incendiary bomb, devolves directly upon the householder. He owes this duty not only to himself but to his community, State, and country. This responsibility involves the provision of the necessary fire-fighting equipment and the knowledge and will to use it. In this connection, the householder cannot always depend upon the usual household water supply from city mains. If there are any considerable number of fires, it is probable that so much water will be consumed by the fire department that there will be little or no water pressure in house pipes. Likewise, special fire-fighting equipment which depends upon electric power lines of the city should not be relied upon, for these lines may be broken. This responsibility of the householder applies also to the owners of apartment houses, hotels, factories, or other buildings where a number of persons are congregated. All necessary special equipment and trained personnel for dealing promptly with incendiary bombs should be present in such buildings at all times when the city is subject to air attack.

The regularly organized fire departments can afford protection against fire only if they are notified promptly in the event of fire. It must be emphasized that delayed alarms are probably one of the principal causes of large and disastrous fires. Under normal conditions the fire department should be called without delay, care being taken to insure that all occupants of the building are promptly notified. This course should be followed during air raids with the one difference in procedure that, instead of calling the fire department directly, the Sector Warden for the district should be notified and he in turn transmits the alarm to the fire department employing facilities available to him. It may be expected that the usual communications systems, such as fire alarm, telegraph, and telephone facilities, will be disrupted either physically or through overload by an abnormally large number of calls. The householders, employees, or other persons at the scene of an incendiary-bomb fire must endeavor with every means at hand to combat the bomb and control the fire. It has been proved that, when used promptly, individual fire-fighting appliances, such as usually are available in the neighborhood, are effective against small to medium-sized bombs, i. e., the bombs up to 12 to 14 pounds. Thus, the successful solution of the problem lies in the cooperative efforts of all concerned. Prompt action by householders will reduce losses and in many cases suffice so that the regularly organized fire departments can concentrate their efforts on fires of major proportions.

SECTION 2.—INCENDIARY MATERIALS AND DEVICES

10. General Classification.—Incendiary materials, according to the way in which they are used, may be classed as:

(*a*) Intensive.

(*b*) Scatter.

The intensive type of material is that which is held together as it burns and is consumed entirely at the one spot where a bomb containing the substance falls or is placed and ignited. The intense heat of the burning material is thus concentrated so that the material's immediate incendiary effect is confined to a small area.

The scatter type is that which is dispersed, usually by an explosive charge, so that small fragments of the burning material are scattered about and thus may cause fires to break out simultaneously in a number of places.

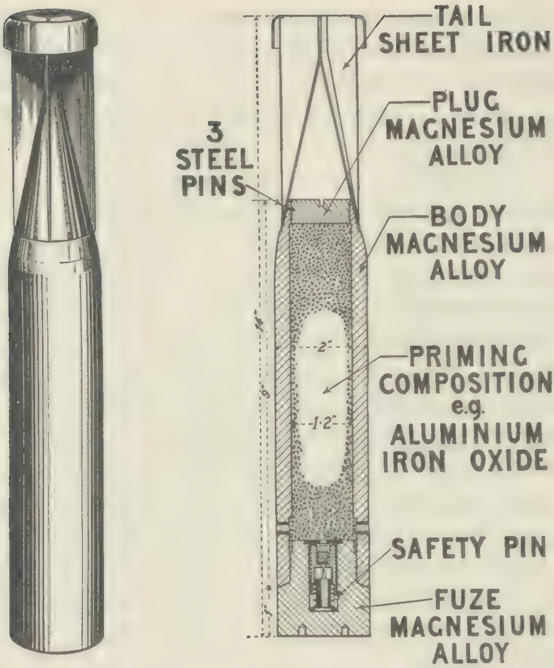
11. Intensive-Type Incendiaries.—(*a*) This class of incendiary substances includes two different kinds or types. One of these types consists of the thermits, which are mixtures of powdered aluminum and iron oxide, sometimes containing small quantities of other ingredients. The thermit mixture, when ignited, reacts chemically to form a mass of molten iron which, in turn, acts as an incendiary in igniting flammable material with which it is brought in contact. The chemical reaction by which the molten iron is produced takes place rapidly and with considerable violence. It does not depend on a supply of oxygen from the air. However, any incendiary action of the molten iron will depend upon a supply of oxygen from the air.

(*b*) The second type of incendiary material, commonly called "electron" bombs, is represented by a magnesium alloy case containing an igniting core of thermit that is ignited by a "first fire" mixture such as aluminum powder, barium nitrate, and black powder. The magnesium alloy case is ignited by a relatively small charge of the ignition mixture and the case itself then melts and burns with a very high temperature until consumed. Magnesium alloy, to burn, must be supplied with oxygen from the air or surrounding material. A considerable percentage of the electron bombs contain a small explosive charge which is added primarily to discourage fire fighters from approaching the burning bombs. The action of this explosive charge is delayed, but if there has been no explosion 2 minutes after the bomb lands, it is probably safe to remove the bomb with a long-handled shovel.

12. Scatter-Type Incendiaries.—(*a*) The most generally used and generally effective scatter-type incendiary material is white phosphorus, which burns spontaneously on exposure to the air producing an intense white smoke. It thus lends itself to use in munitions containing an explosive charge sufficient to rupture the container and disperse burning pellets of phosphorous over a considerable area. The burning phosphorus particle, when it lands, may set fire to dry grass or other easily combustible material. Phosphorus will not set fire to heavy planks or heavy wooden construction but will set fire to wood shingle roofs, dry grass, ripe grain, and woods.

Due to the intense white smoke produced, phosphorus bombs are more likely to produce a panic than fire, and thus prove a demoralizing agent rather than an incendiary.

(*b*) Another scatter type of incendiary is solid oil to which there may be added finely divided metallic sodium or potassium or sodium hydride. The purpose of the latter ingredients is to rekindle the fire in case the oil comes in contact with water, either at the hand of a fireman or by other means.



TYPICAL KILO MAGNESIUM (ELECTRON) INCENDIARY BOMB

(*c*) Liquid flammable oils are also included in this general class. The violence of their burning may be increased by diluting with gasoline, turpentine or other highly flammable liquids which are, mutually soluble with the oil. Such incendiary material, on burning, produces tremendous heat. However, the relatively large volume or bulk of such liquids in comparison to their weight militates against their use in small bombs. Their principal use in warfare is in flame throwers.

(*d*) Squares of cardboard or other combustible material containing a small amount of phosphorus at the centers, called "incendiary leaves," have been scattered promiscuously in great numbers from airplanes. The "incendiary leaves" are kept wet until after they are scattered, whereupon they burst into flame as they become dry. The incendiary squares are particularly likely to set fire to fields of ripe grain, dry woods, or combustible roofs.

13. Incendiary Bombs.—(*a*) *Intensive Type.*—Incendiary bombs may be produced in any size or weight desired, subject to the carrying capacity of an airplane. Large bombs, weighing 50 pounds or more, may be used in certain cases but, in general, small bombs, which can be employed in large numbers simultaneously, are considered most effective. Typical of such bombs is the so-called "electron bomb," used extensively in the war in Europe. This is a magnesium alloy bomb, consisting of a cylindrical case 2 inches in diameter and 9 inches long, made of magnesium alloy and containing a charge of readily ignited powder. Metal fins are provided on one end to steady the bomb in flight and to cause it to strike on its nose. Upon impact, an ignition device inside the bomb is actuated, thus firing the starting mixture, which burns with sufficient heat to ignite the casing. The bomb weighs about 2½ pounds and will burn for 15 to 20 minutes.

Another intensive-type bomb that calls for exceptionally well-planned defense activities is the thermit bomb. It is composed of a thin, noninflammable case filled with thermit that is ignited by a "first fire" mixture. Such bombs are made in sizes ranging from perhaps 10 to 132 pounds and are fired either with a firing pin on impact or with a time fuse so set as to ignite at a predetermined time after release. It is believed that Japan is prepared to use thermit bombs of both 33- and 132-pound type and that Germany may be expected to do likewise.

(*b*) *Scatter Type.*—White phosphorus bombs as used by the Japanese are of the 15 kilogram (33 lb.) and 50 kilogram (132 lb.) types. They are composed of a charge of white phosphorus and a burster charge in a thin steel container. When exploded the white phosphorus is showered in small particles over an area of 50 to 100 square yards, depending upon the size of the bomb. The particles of white phosphorus ignite upon contact with the air and will be burning shortly after leaving the shell, producing a spectacular incident. As incendiary agents the particles are very limited, igniting only dry and flimsy materials such as dry grass, leaves, etc.

The greater danger from white phosphorus bombs is in the possible contact of particles with the human body, in which case they produce serious burns.

When white phosphorus burns it produces an intense white smoke and is commonly used for smoke screens. The smoke is harmless, though it may produce mild throat irritation and coughing. Because of its appearance and the throat irritation the use of white phosphorus bombs might be demoralizing to unsuspecting and unknowing civilians and even cause panic.

TYPES OF INCENDIARY BOMBS

Type of Incendiary	Size	Composition	Method of Extinguishing
Small "Electron" bombs.	1 kilogram (2.2 pounds).	Cylinder of combustible magnesium alloy containing thermit mixture to ignite the magnesium alloy. May contain an explosive charge.	Spray (not a stream) of water. Cover with sand. Remove with long-handled shovel to a metal container with layer of sand in bottom.
Medium and large "Electron" bombs.	2–25 kilogram (4.5 to 55 pounds).	Same as above. All large incendiary bombs will contain some explosive.	Same general methods as above but experienced fire fighters are required to handle the largest bombs of this type.
Thermit.	15 kilogram (33 pounds). 50 kilogram (132 pounds).	Noninflammable case containing mixture of iron oxide and aluminum (thermit) ignited by a "first fire" charge that is ignited either by impact or fuse. May contain an explosive charge.	Burning thermit cannot be extinguished. Molten iron produced may be cooled to reduce spread of fire.
White phosphorus bombs.	30 pound (may be of any size).	White phosphorus with an explosive charge to ignite and scatter the phosphorus upon impact.	Water will extinguish burning phosphorus. Copper sulphate solution, if available, is even more effective. Remove all fragments to a safe place and burn. Avoid handling the fragments with bare hands.
Multiple effect bombs.	12 kilogram (26.5 pounds).	Separate incendiary units of phosphorus and magnesium alloy which scatter upon impact and ignition.	The burning magnesium units can be handled in the same manner as the electron bombs. Burning phosphorus can be extinguished with water and then should be removed to a safe place while wet.
Oil bombs.	Large drums.	Fuel oil or solidified gasoline. May contain other combustible substances. Scattered and ignited by a black powder burster charge upon impact.	Smother with sand.
"Incendiary leaves."	Approximately 4- x 4-inch squares.	Moist squares of cardboard or nitrocellulose coated with phosphorus which ignite as they become dry.	Immerse in water or copper sulphate solution. Burn in some safe place. Be sure that all are collected as one unrecovered square may cause a serious fire.

Because of the smoke produced by the burning, phosphorus particles may be easily located, and should be allowed to burn out if possible. If extinguishment is required it may be done by the use of water, but it must be remembered that the burning will be resumed as soon as the particles become dry. Extreme precaution should be taken that the white phosphorus particles do not come in contact with the skin. However, the danger from the smoke produced may be disregarded.

14. Other Incendiary Munitions.—(*a*). *Artillery and Mortar Shells.*—Shells containing white phosphorus for use with artillery or chemical mortars are designed primarily for the smoke-producing effect of the burning phosphorus. Thus, the incendiary action of these shells generally is incidental although the physical hazard from nearby bursts is considerable. Specially designed incendiary shells, containing thermit mixtures, may be used in these weapons.

(*b*) *Grenades.*—Incendiary grenades are small munitions, very similar in construction to bombs, designed to be thrown by hand or projected from a special contrivance attached to a rifle. The hand grenade can be thrown about 35 yards, whereas the rifle grenade can be projected for 200 yards or more.

(*c*) *Flame throwers.*—The flame thrower is a device for throwing burning heavy asphaltic oil or other suitable fuel in a solid stream by means of gas pressure or a mechanical pump. A small device of this kind is designed to be carried by a man on his back, while a larger type may be used from a trench or fighting tank.

Chapter III.

FIRE-FIGHTING OPERATION DIFFICULTIES

Fire fighting under war conditions is complicated by circumstances which affect the transmission of fire alarms and maintenance of communications, hamper the response of apparatus, nullify good fire-fighting practices, deplete sources of water supply and reduce the available manpower.

15. Alarm Communication System.—Existing telephone and telegraph systems, of which many of the wire circuits are above ground, are vulnerable to aerial attack. Underground wire circuits are also subject to damage by bombing. Central offices are vital objectives for attack. These installations must be safeguarded.

Short wave radio is being used more and more for communications within the police and fire departments. Public and private facilities, including signaling systems in industrial plants and amateur radio equipment, must be coordinated. Provisions for messenger service must be included in any plan.

16. Road Obstructions.—Craters from high explosive bombs and debris from demolished buildings will make some streets impassable to vehicles. Decentralization of fire apparatus is one factor to consider in overcoming this condition. Intimate knowledge of all routes is essential to drivers of apparatus and provisions must be made to keep this information up to the minute for the chief and company officers and dispatchers as well as the drivers.

17. Water Supply.—Water supply may be seriously affected by bombing. The probability of many simultaneous fires scattered over a wide area makes it essential that consideration be given to the advanced development of plans and records to permit emergency operation. Auxiliary sources of water supply must be considered and provisions made for their use, including precautions against contamination of the domestic water supply.

18. Operations During Bombardment.—The fire department will be required to operate at fires during the progress of aerial attacks. The personnel must be on the alert to seek whatever shelter may be at hand to escape the effect of falling bombs, fragments from antiaircraft firing, and possible strafing activities of enemy planes, while at the same time, continuing the attack on the fire. Auxiliary forces must take care of incipient fires in their areas, leaving the major fire-fighting equipment and forces available to combat seriously threatening fires. Fire Watchers should be assigned in advance to definite posts which will be taken upon the sounding of an air-raid alarm.

19. Blackouts.—Response of apparatus and operations at fires will be hampered by "blackout" restrictions. Drivers will need to proceed with extreme caution to avoid accidents. Firemen will meet great difficulty since they must work in total darkness, other than the illumination offered by the fires themselves. Complete familiarity with all apparatus and equipment, and a first-hand knowledge of the fire district are essential in meeting "blackout" conditions. Hand equipment should be painted chrome-yellow or some similar color to render the pieces more visible.

20. Injuries to Firemen.—Abnormal casualties may be expected in the fire force and first aid must be part of the training of these units. The multiplicity of fires and long hours of arduous duty and danger will limit the physical endurance of the firemen. Adequate relief forces will be needed to afford the men sufficient recuperation periods.

21. Rescue Work.—The fire-fighting units must be reserved for fire-fighting purposes wherever possible, but conditions may require the force to aid the separate units organized for rescue, demolition, decontamination, and similar work.

22. Fire Stations.—Fire-alarm equipment and cable facilities must be protected by sand bags or by reinforcement of structures against bombing or the collapse of buildings. Fire apparatus should be distributed in order to facilitate response and to prevent destruction of several pieces if any building should be demolished.

Chapter IV.

FIRE DEFENSES

23. General.—(*a*) The problem of providing adequate fire protection divides itself into two phases:

(1) Use of regular fire-fighting facilities of the community, and

(2) Provision of additional fire-fighting organizations, equipment and facilities to meet the demand resulting from attack by a hostile power.

(*b*) The adequacy of existing fire defenses varies greatly. In many communities, these facilities are seriously deficient. As a first step in planning for defense, necessary improvements should be made in the existing fire-fighting facilities, including the fire department, water supply, fire alarm and related services, to afford adequate protection against the normal fire hazard of the community.

(*c*) Fire departments and other municipal agencies should have plans for expansion to meet the growth of industries and housing in their communities. The local defense coordinator may secure from the Fire Underwriters Board or Bureau information as to the adequacy and efficiency of the local fire defenses. Recommendations from such a source, based on standards established by experience, will provide a sound plan for improvement of local conditions.

24. Fire Department.—(*a*) The responsibility for control of fires rests primarily with the regularly organized fire departments. Some changes may be required to place the fire departments upon an emergency basis; existing apparatus may be relocated or additional fire companies or locations established.

(*b*) *Distribution.*—Distribution of fire-fighting forces is of even greater importance than under normal conditions. For efficient protection in normal times fire department companies should be stationed within three-fourths of a mile running distances from all parts of industrial and mercantile districts, and within 1½ miles from all sections of closely built residential districts. Under emergency conditions, this coverage must be supplemented.

(*c*) *Manpower.*—In order to maintain the department at the highest possible effective strength, the off-shift and any relief men must be subject to call for all emergencies. In order to have the personnel at a high standard of physical condition, arrangements must be made for relief and rest periods.

(*d*) *Apparatus*.—In order to use the manpower of the department effectively, extra apparatus if available should be in service for each company. Reserve apparatus will be needed for this regular service.

Additional standard equipment and improvised apparatus, consisting of commercial trucks carrying pumping equipment, hose and other fire-fighting appliances, may be needed.

(*e*) *Private fire brigades*.—A survey should be made of all private fire brigades, including the facilities of industrial fire departments, their equipment and organizations. Such surveys will reveal the extent of assistance to be expected from private fire brigades or whether assistance from the municipal forces will be needed in the areas served by those organizations.

(*f*) *Aid from other municipalities*.—Aid from other municipalities in apparatus and men can be arranged for on call but, excepting where communities are immediately adjoining and the alarm systems are integrated, reliance should not be placed upon outside aid during attacks.

(*g*) *Emergency operations*.—Plans for operations will differ basically from the normal. In the event of attack, each station is responsible for the protection of its district and may have to operate alone. The regular units must be dispatched first to the fires which constitute the greatest threat to the community or its essential points. Areas where fire walls or fire breaks may confine the spread of fire may be left to the fire wardens to permit the regular forces to concentrate at the more serious fires.

Confidential surveys and operating plans are a prerequisite to the proper execution of this program and should be undertaken by the fire department officer in charge of each district, in cooperation with the chief of the department, and the local Director of Civilian Defense.

25. Water Supply.—(*a*) The importance of the public water supply, both from the standpoint of public health and fire protection makes it essential that every precaution be taken to assure the continuance of an adequate, reliable, and pure supply.

(*b*) *Survey*.—There should be an immediate survey of the water system to determine vital points at which failure might occur in the source of supply, pumping stations, and distribution systems. Particular attention to the following items is necessary in any plans to lessen the possibility of total interruption of service.

(*c*) *Adequacy*.—In addition to the amount of water required for domestic and industrial uses, plus normal fire-fighting demands, it will

be necessary to provide for the greatly increased demands of numerous simultaneous fires, some of which may be of major proportions. The usual supply works will be taxed to full capacity. Plans must contemplate the use of additional sources of supply and storage, including lakes, rivers, cisterns, wells, industrial supplies, tanks, and swimming pools.

Any plans for connections between the water system and auxiliary sources of water supply must include provisions for treating the raw water to prevent contamination of the public water supply. Such connections must not be made except in emergency.

(*d*) *Reliability*.—Duplication of essential parts of the water system, such as the sources of supply, pumping stations, supply mains, and major control points, provides the best means of assuring reliability. Where duplication is not feasible, additional sources, storage, or connections to other supplies are necessary. Stand-by pumping service, using internal combustion engines, located at a distance from the main pumping station, is desirable.

(*e*) *Distribution system*.—A survey of the water system will reveal weak points where a single failure might cause interruption or serious curtailment of service. In planning for emergencies, consideration should be given the following:

(1) Installation of additional control valves at strategic intervals along arterial and other important mains.
(2) Provisions for added ground cover over important mains.
(3) Duplication of important bridge crossings or exposed mains.
(4) Arrangements for adequate safeguards against sabotage and aerial destruction of vital points, by patrolling and camouflage.
(5) Extension of system to unprotected areas.
(6) Preparation of map and sufficient number of plat books showing data relative to the operation of all valves to facilitate isolating sections in which breaks occur.

(*f*) *Emergency operations*.—Emergency ground crews, organized, equipped, and trained to make shut-offs, repair or replace damaged mains, are essential to the defense plans. Provisions must be made and materials kept readily available for by-passing ruptures in important mains; fire hose lines can be used to interconnect hydrants on either side of a break during repairs. The fire department must be acquainted with the water system in order to cooperate effectively with the water department.

(*g*) *Additional sources.*—In addition to the sources of water which may be used to supply the water system, advanced preparations must be made to employ all available water for fire fighting.

(1) *Natural.*—In order to make full use of available lakes, ponds, rivers, and streams, suitable ramps or platforms and possibly low dams or suction pits will be required to enable fire pumping engines to draft water. Every precaution must be taken to prevent water from untreated or contaminated sources from entering the domestic water system. Fire pumping engines drafting water from untreated sources must not be connected in any way with hydrants or hose lines through which impure water might enter the water mains.

(2) *Waste water.*—Sewers may be blocked off by inflated bags and gutters may be dammed to allow waste water to be pumped.

(3) *Improvised storage.*—Cisterns or improvised storages, such as canvas tanks, may be required in areas where natural sources are not available to supplement the water distribution system.

(4) *Portable supplies.*—Fire pumping engines which carry booster tanks provide a limited supply readily available for use in small fires; these tanks may be replenished by bucket brigades. Street flushing tanks may be used for additional supply or may be provided with small size pumps for fire fighting purposes.

(5) *Other possible sources.*—Many buildings with air conditioning systems such as hotels and theaters have wells which can be adapted to fire fighting use.

26. Advanced Planning.—Advanced planning with complete understanding of the emergency plan by all responsible parties is essential to successful defense. Confidential surveys and operating plans should be undertaken by the department heads concerned, and detailed operating procedures determined so far as is practical. In any emergency operation, simplicity of plan is of prime importance in the accomplishment of the desired end.

Chapter V.

EMERGENCY ORGANIZATION

SECTION 1.—AUXILIARY FIRE FORCE

27. Organization.—The auxiliary fire force consisting of an organization of well-trained and disciplined personnel, to augment the regular fire department forces in times of emergency, should at all times operate under the direct supervision of the regular fire department. Auxiliary fire-fighting forces should not supplant, in any way permanent personnel.

The function of this auxiliary force is to assist in the manning of regular, reserve, or additional improvised apparatus and equipment. In some cases separate auxiliary fire companies may be established at new locations, as substations of the regular fire companies. Members of this force should have definite assignments and should be subject to call for duty as required.

The Fire Chief will determine by survey the number of auxiliary companies needed.

28. Personnel.—Personnel for the organized auxiliary force may be drawn from the following sources:

(*a*) Able-bodied pensioned members of the regular fire department.

(*b*) Eligibles on the Civil Service list for appointment to the regular fire department.

(*c*) Other able-bodied citizens who can stand the rigorous duties. Men entering this branch of the fire-defense services should possess physical qualifications which will assure their being capable of performing the required duties.

(*d*) Enrollment of men within the age limits established for Selective Service should be limited, insofar as possible, to those whose service has been deferred and *who have been assigned a low priority*.

(*e*) The number of men for an auxiliary company will be determined by the Fire Chief.

29. Training.—It will be necessary to establish a regular training program, varying from a modified brush-up course in the case of pensioned members who are recalled for duty, to a complete elementary course in fire protection and fire fighting for the inexperienced personnel. A follow-up training program to maintain the interest and efficiency of this force over periods of comparative inactivity,

must be employed. State and local firemen training courses, many of which have been in operation for a number of years, provide facilities for training key personnel.

30. Apparatus.—(*a*) Pumping units must be provided to deliver sufficient quantities of water at satisfactory pressure for fire fighting. It may be expected that pressures in the street mains will be lower than normal and in some cases it will be necessary to depend upon natural water sources.

(*b*) Regular fire department pumping apparatus should have at least 500 gallons per minute pump capacity and carry the standard fire department equipment. Available reserve apparatus will be placed in service.

(*c*) *Additional equipment.*—Pumps of at least 500 gallons per minute capacities and a specified minimum of hose, tools, and appliances will be required to augment the regular fire department apparatus.

(1) Commercial trucks with front or mid-ship mounted pumping units with direct drive or power take-off from the propelling motor.

(2) Pumps with independent internal-combustion engine drive, mounted on truck bodies, or on two- or four-wheel trailers. They must be either self-propelled or capable of being towed behind trucks. A trailer and towing medium forms a unit.

(3) Tank trucks of a commercial type or commercial trucks carrying 250- to 500-gallon water tanks will provide portable supplies of water. Such units if equipped with booster pumps (100 gallons per minute) may be used as emergency fire-fighting units. Street sprinkler trucks can be adapted to this service.

31. Equipment.—Provision must be made for essential fire-fighting tools and appliances with each unit of emergency apparatus. The equipment suggested for these units is as follows:

One 14-foot ladder.
One 24-foot extension ladder.
One pick head ax.
One door opener.
One crowbar.
One pike pole.
Two electric lanterns.
Two Bureau of Mines gas masks.
Two ¾″ nozzle tips.
Two 1″ nozzle tips.
Two 1⅛″ nozzle tips.
Two 5/16″ nozzle tips.
Six hose and ladder straps.
One hose jacket.
Two 4½″ spanners.
One 2½″ spray nozzle.

One 4½″ strainer.

One reducing coupling, 4½″x 2½″.

One double male, 2½″.

One double female, 2½″.

Two playpipes with handles, 2½″.

Two 2½″ shut-off nozzles.

One pair bolt cutters, 30″ handles; ⅜″ bolt.

One 1½″ spray nozzle.

Two 1½″ shut-off nozzles with ½″ tips.

One 2½″ x 1½″ x 1½″ gated wye.

Four 12-quart buckets.

One scoop shovel.

One 100-ft. ¾″ rope.

One first-aid kit.

Two 10-foot lengths of 4″ hard suction hose with 4½″ couplings.

One 20-foot length of 3½″ soft suction hose with proper couplings.

One double female coupling, 4½″ x 4½″.

Six 2½″ universal spanner wrenches.

Two adjustable hydrant wrenches.

Two 4-gallon pump tank extinguishers.

Two adapters, 2½″ to 1½″, 1½″ to garden hose.

One 2½″ wye, 2½″ x 2½″ x 2½″, not gated.

One 2½″ siamese connection with clapper valve.

One lot of miscellaneous equipment and adapters for mutual aid.

An essential item of equipment for *every* piece of fire apparatus is a ten (10) gallon container of pure drinking water. Fire fighters must not be permitted to drink any water which might be contaminated. This is of particular importance during major fire-fighting operation because of the need for large quantities of drinking water by fire fighters.

In the event of a breakdown of equipment during fire-fighting operations, calls for assistance should be made through the person responsible for dispatching apparatus whether it is the regular dispatcher or the control center.

32. Care of Apparatus.—The maintenance and repair of fire-fighting apparatus which includes the regular fire department equipment and the auxiliary equipment should be under the direct supervision of the mechanical repair force of the fire department. Simple, comprehensive, and definite rules for the operation and servicing of the equipment, including the handling of gasoline, should be made available for the emergency units as well as the regular fire department. However, the repair and adjustment of such equipment is the direct responsibility of the fire department and must be undertaken only by the regularly assigned maintenance force. Service and inspection

reports on each piece of apparatus should be kept by the operators assigned to each piece of apparatus.

Strict adherence to established rules for the care of equipment and apparatus, including the care and treatment of hose and equipment, such as, hand pumps, entry tools, and ladders, must be observed in order to assure the availability and serviceability of fire-fighting equipment. No one should tamper with the mechanical equipment or pumping unit and only the regularly appointed operators or members of the mechanical maintenance force shall operate or adjust such equipment.

SECTION 2.—NEIGHBORHOOD FIRE WATCHER PLAN

33. General.—Continuous observation to discover fires as they start, to locate incendiary or explosive bombs, and to extinguish incipient fires, are essentials in successfully overcoming the menace of aerial attack. Local Fire Watcher groups, in every Wardens' Sector of the community, organized under the Air Raid Wardens' posts but trained by the fire department, provide the basis for successful defense.

Through the proper functioning of the Fire Watcher plan, the full effectiveness of the regular fire-fighting forces and auxiliaries can be realized.

34. Organization and Personnel.—Fire Watchers and the personnel of Fire Watcher groups should be chosen from men of established reputation who are residents, shopkeepers, professional workers, or employees in the vicinity. Assistant Fire Watchers should be designated to act in the absence of anyone assigned to a post. Fire Watchers must be capable of directing the work of others and in the selection of these leaders consideration must be given to their availability at all times. They need not be on duty at all times but should be available when needed. The Air Raid Wardens should maintain rosters to assure that the minimum number of men will be in the sector in emergency.

(*a*) *Residential districts.*—Each city block in residential areas requires as many as 5 men besides the watcher.

(*b*) *Other districts.*—Larger units are needed in mercantile, industrial, apartment, or tenement districts. At least 10 men who live or work nearby, in addition to the Fire Watcher, must be available at all times; duplicate units may be organized for day and night.

(*c*) It is recommended that Fire Watchers and their helpers be organized in groups of three, with provision for adequate coverage of each block.

(*d*) Sufficient Fire Watchers should be enrolled and trained to ensure constant vigil and prompt action according to the Air Raid Wardens' estimate of the needs of this section.

35. Training.—The fire department should provide the general supervision and basic instruction in fire-fighting methods for the Fire Watcher groups. The training of each unit is the responsibility of the Air Raid Warden. Intimate knowledge of structural conditions and emergency fire-fighting equipment within the district is of greatest importance. Each unit must be organized and trained to function independently of the fire department in discovering and extinguishing incipient fires, and in directing the householders, merchants, and other civilians in combating such fires.

36. Fire Watcher Equipment.—Fire-fighting equipment for the Fire Watcher groups will normally be of the manual type. Garden hose with a spray nozzle tip will give a suitable stream for this type of service if the domestic water supply provides sufficient pressure.

(*a*) *Hand pumps.*—Hand pump type of extinguishers and back pack type pumps are particularly well suited to Fire Watchers. This type of equipment is effective on small fires and incendiary bombs and is readily carried to the scene of fire.

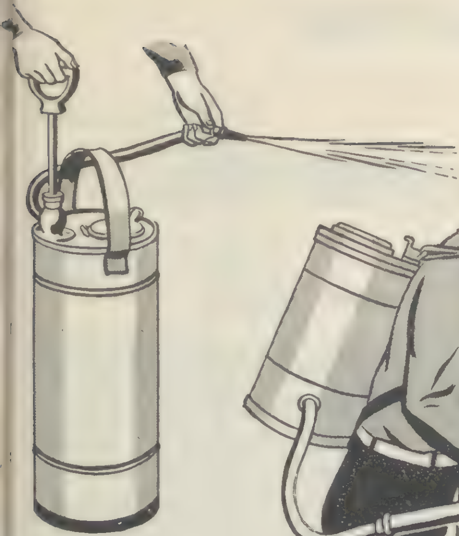
(*b*) *Pump tanks.*—Any good metal container of sufficient capacity can be used. A good hand pump, such as a sturdy bilge pump, with 10 or 15 feet of small hose will suffice. Bucket brigades will be required in many instances to furnish water to these containers.

(*c*) *Ladders.*—Sufficient ladders which can reach roofs of buildings will be needed. In high buildings, the interior stairways, or other natural means of access must be depended on, or the regular fire department called. Ladders should be of the extension type as well as the straight type with roof hooks and folding attic ladders.

(*d*) *Other equipment.*—Each Fire Watcher should have access to equipment of the following type: Axes, jimmies, or other entry tools, ceiling removers, buckets, shovels, ropes, and a first-aid kit.

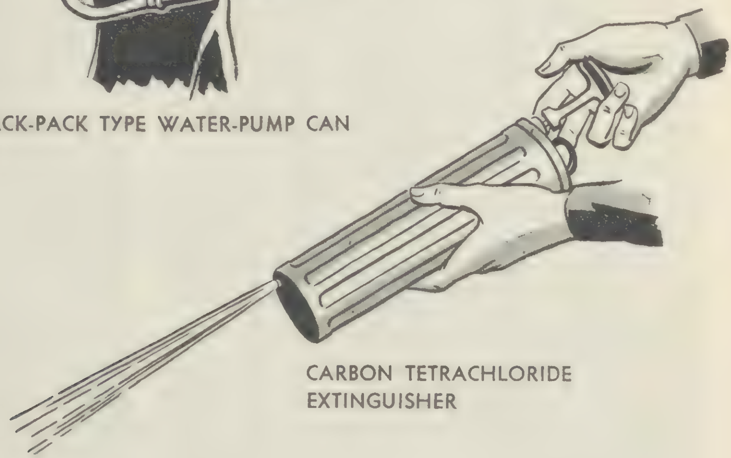
37. Fire Watcher Operations.—These units, under the direction of the Air Raid Wardens, go into service, without call, at time of air raids. Each unit is responsible for the protection of its own area. As fires are discovered, immediate steps are taken to extinguish them with the means at hand.

Fires that cannot be controlled by the watchers are reported to the fire department control office by the Air Raid Warden, with a clear statement of the extent and trend of such fires.



TYPE OF
PUMP CAN
ANOTHER

BACK-PACK TYPE WATER-PUMP CAN



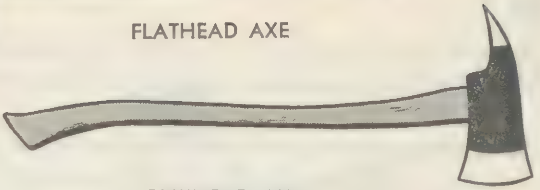
CARBON TETRACHLORIDE
EXTINGUISHER

Continuous observation during raids must be maintained by the Fire Watcher groups in order to detect fires as they start and avoid delay in summoning fire-fighting apparatus.

38. Fire Watchers' Posts.—Observers located on high buildings and other elevations can promptly transmit to the fire department through the Air Raid Warden the location of all visible fires. The number and location of the fire watch observation posts will vary according to the character of the district and topography. A telephone in such locations is desirable.

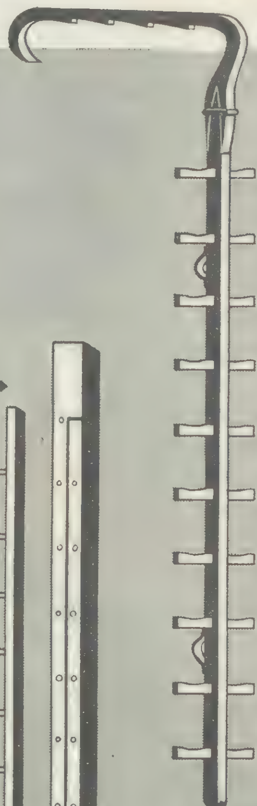
When reporting the location of a fire, observers should indicate whether it involves a large area, such as a city block or industrial plant, or if it is apparently confined to one building.

FLATHEAD AXE

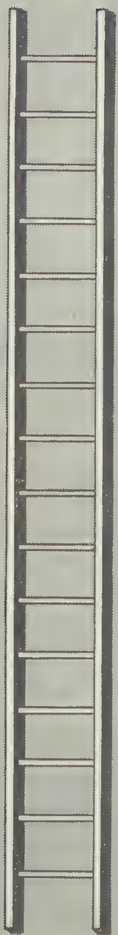


PICKHEAD AXE

ROOF LADDER



POMPIER LADDER OR SCALING LADDER



STRAIGHT LADDER

COLLAPSIBLE LADDER

Chapter VI.

COMBATING INCENDIARY BOMB FIRES

39. *General.*—A fire in a house caused by an incendiary bomb is no different from a fire due to a more common cause, and is dealt with in the same manner as any other fire. It is only in dealing with the bomb itself that special precautions are necessary. The procedure described herein is for the guidance of the average house occupant using simple means which can be obtained at small cost and is indicative of the methods which will be employed.

40. *Advance Preparations.*—The first thing for the householder in an area subject to air attack to do is to see that all parts of his house are readily accessible. Bombs released from a considerable altitude will be falling almost straight downward as they near the ground, hence in most cases those which penetrate a house will first strike the roof. Even quite small bombs will penetrate any ordinary roof. If the attic or other air space immediately underneath the roof is floored over, the bomb will probably come to rest on that floor. Unless dealt with promptly, however, it will burn through a floor in a few minutes and fall to a room below. If the space immediately below the roof consists of exposed joists, lathing, and plaster, the bomb will probably crash through this at once to a floor below. Thus in the case of small incendiary bombs, which are the type most likely to strike a dwelling house, usually a fire will break out in the roof or upper story of the house. Hence, all parts of the upper air space or attic should be readily accessible to the fire fighter. If there are obstructing walls closing off parts of such space, doorways should be cut through them. All of the attic or roof space immediately below the roof should be boarded over, leaving no exposed ceiling joists. The floor should then be covered with a layer 2 to 2½ inches thick of sand, ashes, finely sifted earth, blast furnace slag, or other such fire-resistant material. Sand has the disadvantage of being particularly heavy. Whatever material is used care should be taken to insure that the floor will withstand the added weight.

A corrugated or plain sheet iron covering is not recommended. It will protect against sparks, but the area beneath and about the bomb is likely to become red hot thus spreading the fire, and also such material is an obstruction in case it becomes necessary to use an ax

to get at the ceiling joists or ceiling below the floor. Interior parts of the roof structure, walls, and joists may be coated with a fire-resistant plaster as an added precaution. Even a coat of whitewash has some value. It is desirable to remove all furniture, boxes, trunks, etc., from this area to decrease the fire hazard and also to facilitate free movement of the fire fighter. In any case, all trash, paper, and other easily inflammable material should be removed. If the roof of the house is flat and will stand the added weight, it is well to cover it with a 2-inch layer of sand or other such material. The next step in advance precautions is to obtain the necessary fire-fighting equipment and place it where it will be readily accessible. It should be inspected frequently to insure its constant readiness for use, and all adult members of the household should know how to use it.

It should be understood that the above precautions apply only to the smaller magnesium bombs, and that practically no precautions other than the removal of inflammable material can be taken against thermit bombs. Being of the 33- and 132-pound type, it must be expected that a thermit bomb will penetrate farther into a building than the small bombs. Due to its very nature, the thermit bomb will burn its way through other floors and a major fire will result.

41. Equipment.—The following items of equipment are recommended: At least 10 gallons of water, preferably in two or three buckets distributed in various parts of the building.

Note.—Do not empty contents of buckets directly on burning bomb.

Additional larger containers of water, such as washtubs or barrels from which buckets and other containers may be replenished should be kept filled.

A water pump-can, that is a double-action pump which can be employed with attached containers and at least 12 feet of hose attached to such pump. Such equipment should have a nozzle in order to provide both a spray and a solid stream.

A garden hose equipped with quick coupling connectors to fit domestic faucets.

Long-handled shovel.

Heavy leather gloves.

Fire ax.

Coal scuttle, bucket, or special receptacle for use in removing bombs. They should be prepared ready for use with 3 to 4 inches of dry sand covering their bottoms to prevent incendiaries from burning through when being carried.

Lantern or flashlight.
4 red flags and sign marked "DANGER—DUD."
Sand, 2 buckets, on each of two top floors.

42. Number of Fire Fighters.—It is desirable in dealing with an incendiary bomb that there be at least two persons available; one to handle the hose and fight the fire and one to operate the hand pump; a third to keep up the supply of water at the pump by carrying buckets is highly desirable. However, two persons can manage, and even one person alone, if he tackles the job soon enough, may be able to do the the job without assistance.

43. Magnesium Bombs.—(*a*) *Close approach dangerous.*—The intense heat of a burning magnesium alloy bomb will tend to prevent approaching it closely. In any case to do so would be especially dangerous for the first minute or so after the bomb starts to burn, since the starting mixture sputters, throwing out a mass of sparks for some distance and also a certain percent contain a small explosive charge which has a delayed action.

A table, chair or door can be used as a shield for the fire fighter while applying a water spray on a burning incendiary bomb. The use of such shield will protect the person who is directing the hose stream.

(*b*) *Where to start operations.*—The fire fighter must decide in each case whether to deal first with the fire or the bomb itself. If the fire has already gained considerable headway, it will be necessary to get it under control at once. On the other hand, if it has not progressed appreciably, the bomb itself should receive first attention. *If there is considerable smoke, the fire fighter should keep his head as close to the floor as possible, shielding himself as suggested in the preceding paragraph.* To avoid heavy breathing, he should operate with as little physical exertion as possible.

(*c*) *Use of water.*—It will take usually from 5 to 6 gallons of water to deal with the bomb alone. Hence at least 10 gallons of water and preferably more should be available. The stream from the nozzle should be used on the burning structure and the area about the bomb, but a solid stream should not be directed upon the bomb itself. For treatment of the bomb with water the nozzle should be adjusted to throw a spray. Water is the best extinguishing agent—and a moderately coarse spray without a great velocity of water has been found to be both safe and effective. It should be understood that water cannot be expected to extinguish the bomb but causes it to burn faster and more intensely. The value of water is that it causes the

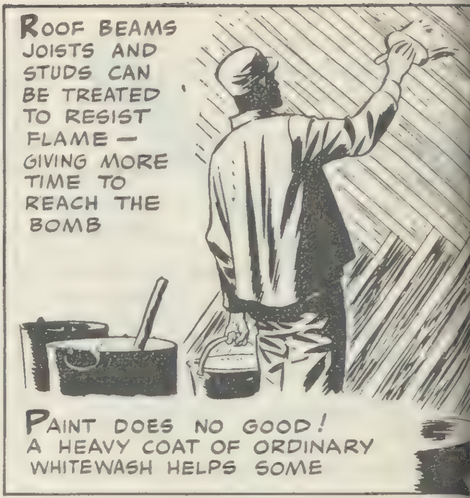
bomb to be consumed and thus gotten rid of in a fraction of the time which it would otherwise take for it to burn out. A solid stream should not be directed on the bomb, although a solid stream may be used effectively to cool down surrounding materials and thereby confine the effect of the bomb. Tests show that solid streams striking a bomb cause an explosion which may be dangerous to the persons fighting the fire. A spray which will put water (not a solid stream) on a bomb at a distance of not less than 12 to 15 feet is the most effective for any size hose. Another reason for not directing a strong stream of water on the bomb is that such action will disperse the molten metal. In no case should a bucket of water ever be thrown upon a bomb of this type. Copper sulphate solution is particularly well suited for dealing with white phosphorus bombs, and may be used in lieu of water on other types.

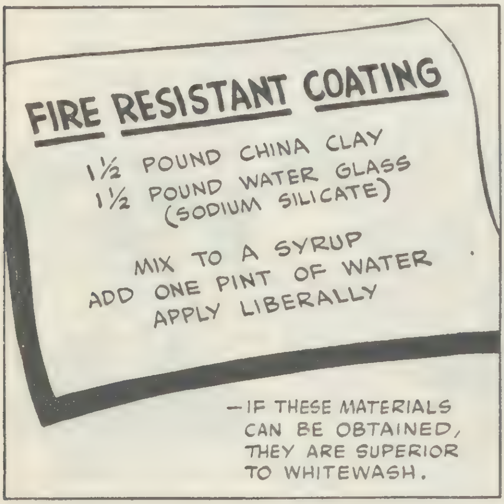
(*d*) *Use of sand or similar material.*—Where it is possible, dry sand or even earth may be used. This action reduces the supply of oxygen so that the bomb burns less violently. The amount of heat given off is reduced, and the dazzling glare of the burning metal is stopped. It should be realized, however, that the bomb thus covered is not put out and will burn through the floor in a few minutes unless removed. However, the bomb can now be approached more closely. Using a long-handled shovel or specially designed long-handled scoop with detachable hoe the bomb may be raked into a coal scuttle, bucket or similar receptacle. A 4-inch layer of sand or similar material should first be placed in the receptacle, otherwise the bomb may burn through the bottom of the vessel before it can be carried out. The vessel should be carried on the end of the shovel or a pole. While the bomb is being removed, it is desirable that a second person be present to fight the fire.

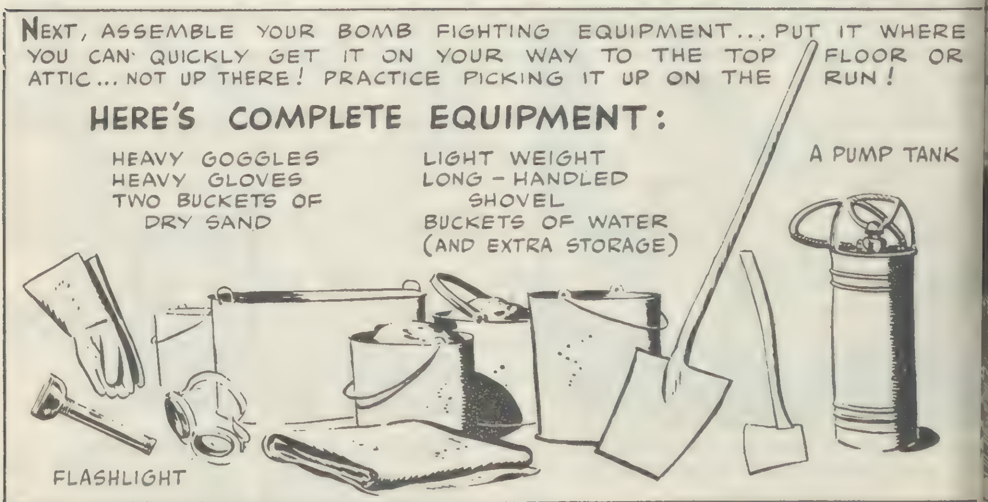
(*e*) *Use of chemical extinguishers.*—Water has been found to be the best extinguishing agent for bombs of the type used at the present time. The quenching effect of water observed in tests on incendiary bombs is most effective. Fire extinguishers employing a water base, such as the soda-acid or foam type are effective. Carbon dioxide and carbon tetrachloride extinguishers have by test been found ineffective on these bombs, but will put out fire resulting from the bomb action. The average extinguisher is of about 2½-gallon capacity, and this amount of liquid would in most cases be insufficient to deal with both the bomb and the fire. Thus, several extinguishers should be on hand. Certain types of chemical extinguishers, while excellent for the purpose for which designed, are not especially suitable in meeting a situation caused by an incendiary bomb.

W THE MAGNESIUM BOMB WORKS

FIRE DEFENSE







NTROLLING WITH SAND

CONTROLLING WITH WATER

ABOUT FIRE EXTINGUISHERS

Many houses and public buildings have fire extinguishers. They will be as useful as ever in putting out fires caused by an incendiary bomb. For putting out the bomb itself, the extinguisher may not be suitable.

Read the label. If it says that the contents include CARBON TETRACHLORIDE, it cannot under any circumstances be used on a magnesium bomb. It is not only ineffective, it may cause dangerous gas to be generated. After the bomb is burnt out, use it on any remaining fire.

All water-type extinguishers are suitable. If the label says SODA-ACID, that's simply a means of creating pressure in the extinguisher. Turn it upside down, use it. You can get a spray effect by putting the thumb over the nozzle, use the jet on surrounding fires. However, *one extinguisher is not enough to burn out a magnesium bomb.* And you cannot refill the extinguisher.

It is best to have sand or pump-bucket equipment handy, use them on the bomb, and save the extinguishers for resulting fires.

A foam extinguisher will also help to control a bomb, but one extinguisher load will not finish the job.

See that the extinguishers you know about are ready for use.

44. Thermit Bombs.—Bombs in which thermit is used entirely will likely be of the 33- and 132-pound types and an entirely different method of control will be required. The larger bombs will penetrate farther and the fury of the incendiary will be increased many times. It has been determined that a 10-pound thermit bomb will expend itself in slightly less than a minute, and it can be expected that the larger types will require little more time. However, the mass of spurting fire and the resulting amount of molten iron set free to burn its way through floors and ceilings will be quite sufficient to start a serious fire.

It is evident that methods prescribed for controlling a magnesium bomb will be of little use. Due to the short period of time required for the bomb to expend itself, the spattering of burning material from the bomb, and the intensity of the fire, about all that can be done is to report the fire.

Steps may be taken to cool the molten iron that is left to burn its way through. This may be done with a water spray, since iron will not burn readily as does magnesium. A great deal of steam will be caused, but the cooling will lessen the chance of the iron igniting combustible materials.

45. Scatter Type Bombs.—(*a*) *White phosphorus.*—In the case of a white phosphorus bomb it is essential that every particle of the burning material be put out and removed. Copper sulphate solution is excellent for this purpose. When this solution is sprayed or thrown upon the burning phosphorus particles it not only stops the burning, but causes a chemical reaction which results in the formation of a thin coating of metallic copper over the phosphorus particle. After allowing the particles sufficient time to cool and solidify, they must be taken outside, and disposed of by burning. It is essential to find and remove each particle because if one of these particles is stepped upon or otherwise struck so as to rupture the fine copper plating, the phosphorus thus again exposed to the air will take fire spontaneously. Great care should be exercised in dealing with phosphorus. It not only causes severe and painful burns when it comes in contact with the body, but also has a poisonous effect on the system. If copper sulphate solution is not available, ordinary water may be used. It must be realized, however, that as soon as the water or the solution evaporates on any one of the particles, it will again take fire. Because of the relatively low incendiary value of white phosphorus, it is possible that under favorable conditions, it would be better to allow the small particles to burn themselves out while protecting surrounding materials from ignition.

No attention need be given to the intense white smoke produced by burning white phosphorus; it is not harmful. It may prove slightly irritating to the throat and at times cause coughing, but it will produce no serious consequences.

(*b*) *Oil bombs.*—Bombs of this type, if used, generally will be large bombs designed for some degree of accuracy in use against definite targets of considerable military importance. Hence the dwelling house occupant is less likely to encounter these bombs than those of the magnesium alloy type. Such bombs, when applicable, however, are highly effective since the heat produced by the flammable oil mixture is nearly twice that produced by an equal amount, by weight, of magnesium alloy. The incendiary effect of burning gasoline is almost entirely upward, so that a considerable amount burned on a floor may only scorch it. Excepting where pools of oil are formed in such quantities that the fire could spread by the application of water, it appears that water or any of the usual types of fire extinguishers may be employed.

(*c*) *Sodium or potassium hydride.*—Oil bombs containing metallic sodium or alkali hydride, which burn or explode on contact with water, may possibly be used. The best method of dealing with such a bomb is to smother it with sand or a special mixture (sand, dolomite, and salt) or let it burn itself out, meanwhile keeping the area about the bomb wet, but taking care to keep the water away from the bomb itself.

(*d*) *Multiple-effect bombs.*—A type of incendiary bomb designed for use against large buildings but which may be encountered by a dwelling house occupant is the multiple-effect bomb. This is a large bomb, usually weighing 25 pounds or more, consisting of a large number of separate units loaded in a single container. The units are ejected from the container, which is broken apart by an explosive charge or other means after penetrating a building. These units may be of the magnesium alloy type or of the phosphorus type. Each such unit, depending on its type, must then be dealt with separately, as in the case of individual bombs.

(*e*) *Duds and apparent duds.*—Bombs which land without exploding or burning may be "delayed action bombs" and may also be highly explosive. Hence, it is extremely dangerous for the average citizen to do anything with them. The premises should be vacated immediately and the nearest policeman or Air Raid Warden notified.

The job of removing an unexploded bomb is a highly specialized operation delegated to the bomb squad.

46. Use of Gas Masks.—Gas masks provided for protection against war gases should not be used in fighting fire. It should be remembered that such masks do not supply oxygen and that the air in an enclosed space of a burning building may be deficient in oxygen. It also should be understood that dangerous quantities of carbon monoxide are developed in confined spaces of burning buildings or where fires have continued to smoulder, and that the gas masks for war purposes are not designed for protection against this dangerous gas. If the circumstances are such that a mask must be used in fighting the fire, there are three types which are applicable. First is the oxygen helmet or self-contained breathing unit. Another type is the so-called all-purpose mask, which protects against carbon monoxide as well as other gases, but does not aid materially if the atmosphere is deficient in oxygen. The third type is the hose mask, which includes a long hose extending from the facepiece to the outside of the building so that the wearer breathes only the air drawn from the outside.

Chapter VII.

PRIVATE PROTECTION

47. The general principles of protecting factories, warehouses and other important property against incendiary bomb attack are closely related to normal fire protection with due consideration to the special features covered in other sections of this pamphlet. If there is a large amount of material to burn in one place, a large fire is to be expected. From the standpoint of fire protection therefore, it is axiomatic that the amount of combustible material in one place should be as small as possible.

Under ordinary conditions most fires can be prevented from starting through maintenance of good conditions, especially with respect to ordinary housekeeping. Furthermore, good housekeeping is a large factor in facilitating the control of fires once started. The limitation in size and separation of areas; the protection of communications, that is, doorways, stair shafts, and elevator openings; the ready availability of fire-fighting equipment, both automatic and manual; and the training of employees or occupants in the proper use of the fire-fighting equipment are important and determining factors in private protection.

Chapter VIII.

FIRE ALARM SERVICE

48. Existing Services.—The municipal fire and police alarm and public telephone systems provide the means of transmitting notification of fire to the fire department under normal conditions. It is seldom that the municipal fire alarm telegraph system is adequate, and additional street boxes and circuits are generally needed to meet normal requirements.

The existing services are usually dependent upon one or more central offices which may be destroyed or disrupted by aerial bombardment. The wire circuits in these existing systems are subject to disruption, particularly so where circuits are by overhead wires.

In addition to the physical disruption of alarm service, there is the great likelihood that in emergency the large number of calls over the fire alarm telegraph and public telephone systems will overload these facilities to the point that the value of such communications will be greatly impaired or possibly lost entirely.

49. Emergency Conditions.—Provision must be made for utilizing any method of delivering an alarm message. All means must be guarded against disruption by bombs, shelling or sabotage. Local Fire Watcher organizations are essential in this plan.

During aerial attack, the organized fire department can respond only on call by authorized officials, including recognized members of the Fire Watcher service.

50. Extension of Existing System.—Plans made and appropriations provided for installing underground systems should be utilized. Underground circuits are less vulnerable to air attacks, bombs, or exposure fires, than aerial circuits. Such lines, if opposite sides are on different routes and manhole covers sealed, are also less susceptible to damage.

Emergency current sources should be available, using portable gasoline engine driven generators. The fire alarm superintendent should have plans, instruments and materials for the emergency location of a temporary central office, or for the decentralization of central station facilities in the several sections of the city where cables offer maximum facilities, in the event of destruction of the fire alarm headquarters.

51. Telephones.—The telephone system is the main nerve system for notification of all emergencies. In emergencies this system may be overloaded with simultaneous attempts to place calls.

It is essential that definite arrangements be made to assure the most effective use of the telephone system in time of emergency. Persons discovering fires must report to the local Air Raid Warden rather than attempt to communicate directly with the fire department. The Warden, police, or other constituted authorities should be authorized and equipped to transmit alarms to the fire department.

52. Special Telephone Circuits.—Certain lines should be segregated by the telephone companies for the sole use of Air Raid Wardens. In manual systems, colored lights on the switchboard will identify such Warden calls. In automatic systems, additional lines will be necessary, solely for the use of the Wardens. Wardens should have, besides the regular systems, special telephone circuits to the nearest fire-fighting organizations, or to a special section of the public telephone switchboard.

Locked cabinets containing a switchboard should be placed on the street, near the center of the Warden's district. Adjoining cabinets should be on different circuits.

To prevent unauthorized use, only the Wardens should have the telephone jacks and portable telephone instruments, to plug in when necessary.

Such preparations should be made in advance wherever practicable by the civilian defense coordinators.

53. Use of Fire Alarm System During Raids.—In order to avoid confusion from the transmission of numerous simultaneous calls over the fire-alarm system during aerial attack, the public should be instructed to report fires to the district Fire Watchers. Fire Watchers should have keys to the locked portions of fire alarm street boxes which will allow them to transmit an identifying code signal before the call is sent.

54. Private Alarm Systems.—These systems are needed in vital storage warehouses and factories where foodstuffs and war materials are made.

Private organizations usually supply this service over their own lines to the fire headquarters. This furnishes an additional and independent system.

In the absence of such systems, the local alarm services should be connected to operate over the municipal fire-alarm system.

55. *Radio.*—Short-wave radio will be of particular value because of the vulnerability to attack of the regular communication lines. Portable transmitters authorized for use may be located at strategic points for use of the fire service, observation posts and, in some instances, Fire Watchers. Receivers, tuned to these transmitters and to those in police patrol cars, should be provided in each fire station.

In times of war, many amateur radio stations may be advantageously relocated and maintained for district protection and supervision. Portable transmitters must be tuned to frequencies and strengths designated by the Federal Communications Commission.

Provision must be made for the continuance of electric supply for the radio equipment. Standby equipment in the form of batteries or portable plants is necessary to assure service in case of failure of public-utility power plants. Fourteen-pound, two-way portable, battery operated sets will probably be available.

56. *Other Means.*—Any method of alarm transmission, in addition to those previously mentioned, may be used in emergencies, such as runners or messengers, on foot, with bicycle, or in motors.

Chapter IX.

MALICIOUS BURNING

57. *Causes.*—Fires may be started by mentally deranged pyromaniacs, or by others through motives of revenge or personal profit. During attack, more numerous incendiary fires may be expected. People have been known to set fires to their own property during air raids. Such fires will tax the fire-fighting forces and may be very disastrous. Fires from such causes must be anticipated.

58. *Identification.*—The cause of each fire must be noted and, if the fire is of suspicious origin, care should be exercised in checking all pertinent factors with a view to apprehending the person or persons responsible. Holes in a roof or wall will identify those caused by an aircraft bomb. A clever arsonist might use a similar device. A study of the chapter on Incendiary Bombs will aid in such analysis.

If it is determined that the fire was set, everything unusual should be noted after the fire is extinguished, such as odors of gasoline, kerosene, or chemicals, unusual color of the smoke, explosions or puffs of fire due to inflammable vapor or the existence of more than one fire on the premises.

Mechanical contrivances, oily rags, or containers for combustible liquids which are discovered should be preserved and all these findings should be reported to the proper authorities for investigation. Where conditions suggest further investigation, all evidence must be preserved.

Suspicious persons at the fire should be watched and their identities established and reported.

59. Continued Vigilance.—After the air raid is over and the excitement has subsided, a pyromaniac may start new fires as a reaction from the recent excitement. Vigilance is particularly needed at such times as the general population will be inclined to relax following a raid. Alertness will make the work of the arsonists more difficult and prevent other fires.

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Washington, D. C.

Standard School Lectures—
Civilian Protection
Series I

GENERAL SUBJECTS

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ABOUT THESE NOTES

These lecture notes, taken at the Civilian Defense School at Edgewood Arsenal, Md., are offered for the guidance of instructors in local schools. They are fairly complete transcriptions of the lectures as given, except that restricted or confidential matter has been eliminated, and the lectures have been somewhat shortened.

For the convenience of instructors, they are presented in series so that all pertinent material may be assembled in one place, together with any notes the instructor wishes to prepare himself.

Attention is called to Lecture on Organization and Conduct of Local Schools, in series I. This lecture deals especially with expedients and methods of dramatizing instruction; it is included here, not as the material for a lecture to be given by instructors, but for their reference in planning courses.

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IA

REMARKS BY MAYOR LAGUARDIA

to First Class at

CIVILIAN DEFENSE SCHOOL

July 11, 1941

Commanding Officer, Gentlemen:

I am very happy to have the opportunity of coming here this morning because I know that you would want me, on behalf of the cities and States, to express our thanks and appreciation to the Army and to the Chemical Warfare Service, and to the commanding officer of this school. I want to thank you, gentlemen, for the very fine cooperation which you have given us.

You are the first class of its kind. Classes will follow now until we have covered every city in the country.

When you return to your homes to resume your duties you will have the responsibility not only of training your own department but also of training the auxiliary forces that will be enrolled and that we find necessary to supplement existing fire departments, and in making up our air raid warden service.

There is one point I would like to make. I am sure that every one of you will be confronted with these questions: "Why is this all necessary? Does the Army expect our towns to be bombed and attacked?" Of course, the answer is that we do not expect to be attacked or bombed tonight, or tomorrow, or the day after tomorrow, but that this specialized and highly technical training you have taken

is necessary today in view of existing conditions and in the face of an entirely new technique of war.

There was a time when the civilian population did not have very much to worry about in times of war, insofar as their own personal safety was concerned. Cities were not generally exposed to attack. There were forts along the coasts that afforded sufficient protection. All that has changed. The technique of attack has changed, ships have been built larger, the range of guns has increased. And now, with the advent of aviation, there is no longer any such thing as localizing war. It is the cities that are attacked, and the noncombatant population, women, and children, that are actually exposed to attack.

Now, we have seen that distance cannot be relied upon entirely for protection. We are now delivering planes to England, flying them over. A few weeks ago a plane left a certain point in North America and reached a certain point in England in 8 hours. If that can be done one way, it can be done the other way. So the comfort of distance simply does not exist any longer.

You and I are just city officials, and we have nothing to do with shaping the foreign policy of our Government. The American people have delegated that to the President and to the Congress. That is not our job. It is our job to protect the people of our cities and of our States. We do that in case of fire or disease, we afford police protection and health protection. On top of this has come this new responsibility, and that is to give protection to the civilian population in the event our country is attacked or becomes engaged in war. We have the responsibility of being prepared and ready.

I am sure you will all realize that all this is new to us, and it is going to take time, first, to have the necessary training in the permanent departments of our cities, and then to educate the people of our cities to have self-imposed discipline so that they will follow instructions and obey orders in the event of an attack.

In addition to that, every city and community will have to obtain necessary equipment, and no city has that equipment today.

We have taken an inventory based upon the experience of the English cities, and we are now about complete in our estimate as to just what additional supplementary fire-fighting equipment each city should have, and we have taken the engine company as a basis.

We know that we should train an auxiliary fire-fighting force from three to five times the number of the permanent professional fire force. That depends upon the lay-out of the city, the type of construction, and the equipment now available.

These auxiliary companies will have to be equipped, not with the same type of apparatus we now use, but with portable pumpers placed at strategic points, and other necessary equipment that has been tried and found necessary in the English cities. No city in this country and no State that I know of has available at this moment the money with which to buy the equipment that is necessary. And even if we did have the money, the equipment does not exist.

We must also take care that we all agree on the type of apparatus needed. We are now in consultation among the cities concerning the best type of equipment that can

be obtained, again based on English experience, in order to have uniform specifications and uniform equipment all through the country. The reason for that is obvious We discourage cities rushing in and seeking to obtain equipment on their own specifications, and we have a general agreement on that.

It is my intention, as soon as this inventory is completed—and I have conferred with all of the mayors of the country and with a great many of the Governors—to present the matter to Congress and to seek to have Congress provide for all the additional emergency equipment that is required and needed throughout the country. Naturally, the needs along the coasts, Atlantic, Gulf, and Pacific, are much greater than they are west of the Alleghenies or east of the Rockies.

We estimate that it will take from a year to a year and a half to provide all of this necessary emergency equipment, so that we will be in need of additional apparatus for several months to come. In the meantime, we can train our auxiliary fire forces.

Now, when I talk about auxiliary fire forces, I mean just that—companies that will be stationed in the zone of each engine company and that will move out on call to fight fires. That does not include the spot fire fighter, the incendiary bomb spotter. They will be enrolled in the air raid warden service.

In all likelihood, in your respective cities you will have the responsibility of training this part of the air raid warden service. Under our present table of organization, a large percentage of the air raid wardens are trained for spot fire fighting. They use sprays and snuffers and sand. They are placed on roofs, on the streets, and at all strategic

points, and they serve with the air raid wardens. That force is separate and over and above the necessary auxiliary fire forces. In some of the smaller communities in all likelihood you will combine it under one command.

There is another problem that will present itself to you in your respective cities. Naturally, we will want to use the cooperation of all existing organizations—American Legion, Veterans of Foreign Wars, women's auxiliaries, and other organizations. But you men who are experienced know that in times of emergency we must not have any conflict of command or any confusion. I have sought to make that perfectly clear throughout the country.

I have conferred with the heads of most of the national organizations, and they understand the necessity of complete, undivided command and discipline in these auxiliary forces. Therefore, these organizations can help you in enrolling your personnel. They can help in some of the training. For instance, the Red Cross in many localities will continue its courses in nursing and first aid and rescue work on a standard approved by the Office of Civilian Defense. We must have uniform standards. But when their members report for duty to the regular establishments of the city, they lose their identity as members of any specific organization, and become members of the auxiliary fire force or of the air raid warden service.

That must be made clear, because you will readily see the confusion that would result when and if we are called into action, were each of the various organizations working with you to expect that they will command their own members. I think the confusion that would follow would cause greater damage than the bombs themselves. So that must be avoided. Make it very clear at the outset that we need

their cooperation in enrolling members, that they can help in training, but that your regular departments will assume responsibility and command.

Now, the Departments of the cities are the logical departments or agencies to take over this emergency and protective work. The fire departments, of course, are trained to fight fires, and the auxiliary force necessary to meet an emergency is under the direct command of that fire department and becomes a part of it when in action. There can be no division of authority. Where, as in the larger cities, you also have your air raid warden service separate from the fire department, then the commissioner of public safety, or the police commissioner or chief, as the case may be, assumes command, and all of the air raid wardens are under his command and become part of that police department.

When we come to clearance, removal of debris, rescue of people out of demolished or shattered buildings, those squads do not move until they get the clearance. Your public works department or whatever corresponds to that, your street repair department, your water supply department, must all be merged along with your utilities, the telephone and gas companies—they must all be merged into your clearance and repair service. Gas mains, water mains, sewers are all exposed, and may be and are very often shattered and broken, but all of your repair squads must be coordinated, and you must provide these rescue squads, whether they are for telephone, gas, water supply, or sewers, with additional labor divisions, because very often they will require a large number of men to make the necessary clearance so that they can get to the utility to make the temporary repairs.

Your health department comes very close to these repair squads, because if your sewer is in close proximity to your water main and they are both broken, then your health division must come right in and see that there is no contamination. If there is the slightest danger of contamination, they must shut off that supply system in the area that might be infected. Then you must provide for an emergency water supply for the section involved.

You will find that organizing your repair squads will not be difficult because every city and every community has a pretty good nucleus in their road repair, street repair, water supply, and sewer departments. The telephone and gas companies have equipment. While this equipment, available now, may not be quite enough, you must improvise equipment and commandeer trucks. The departments of cities as a rule have a sufficient number of trucks to move your labor battalions out in order to make the necessary clearances and repairs.

Your medical divisions are entirely separate, and your health officer or head of the hospital system or senior medical officer would take charge of that. That is entirely apart and distinct from your line. They will function and come on call when necessary. There will be men and women who are trained in first aid among the air raid wardens, and the rest of your squads, of course, will rescue people and they will be cleared from the field stations to the hospitals.

Now, it is a big job, men. There is much detail to it, and you have had the advantage now of special instructions in a highly specialized and technical branch of civilian protection.

All that we can give our people is this passive defense. It is not our function to fight the enemy off. If the enemy gets by our bases, our Army, and our air force, all we can do is to provide passive defense; that is, to protect the people with no means at all of fighting back. That is not as spectacular as having the weapons and the opportunity to fight back. All we can do is to afford the maximum protection, and one of the most important parts of our work is gradually but persistently to train the civilian population to the necessity of cooperating and following instructions.

Your building departments will classify the buildings in your cities so that the residents of each house will know just exactly what part of the building to go to. The clearance of streets immediately following the first alarm is necessary, and everybody must be off the street.

We do not contemplate at this moment the building of shelters. Judging from the English experience, shelters are being used less and less, although the intensity of the bombing has increased. Therefore, each building must be classified and identified, and the occupants of that building advised just what to do. In every plant you should train the air raid warden for that plant and fire protection. Every plan must have its own emergency squads in addition to your regular city-wide service, so that among their own people they can provide the first protection. If the plant or factory is running 24 hours a day, there should be 3 shifts of men and women trained to do this work. If it does not operate at night, then among its employees living in the vicinity of that plant there should be some who are trained and disciplined to report for the protection

of that particular plant or factory, in the event of an attack.

Uniform instructions and manual of procedure will be provided from the Washington office. Naturally, in all the instructions that come from Washington or from your civilian defense director in your particular corps area, or from your State council of defense or local council of defense, you must remember that they should be adjusted to your local conditions. The instructions can only be very general.

And now, as you go home, please bear in mind that this is only precautionary, just the same as the precautionary measures that the health departments and police departments provide. The health department provides measures against epidemics, not because we expect to have epidemics, but because we must be ready should they come. The same is true in your work of civilian defense.

I want to congratulate you on having had the opportunity of taking this course. I want to thank the faculty of the school and the commanding officer for their kind cooperation. Let the whole world know that while we do things in our own way, we are not goose-stepping into action; we are getting ready, and we are afraid of nobody.

IB

AERIAL ATTACK ON CITIES

The bombing of cities is part of what is called nowadays "total war." The basic doctrine that seems to have influenced most countries is in a book on air warfare by an Italian authority named General Douhet. I do not say that the doctrines of total war from the air are accepted as a whole, but they have influenced the trend of air warfare in two respects. Cities are bombed because they are industrial centers and because they are centers of population or political centers.

Industrial Centers.

Industrial cities provide the enemy's armies with the means of waging war. Modern war cannot be waged without machines—tanks, machine guns, automobiles, trucks, radios. Cannon might be called machines. Those things have to be made in factories. Most factories are located in or near cities, and the factory workers live in cities. Under the conditions of modern war the man in the factory has become a fighter, just as much as the soldier on the firing line. The man who fills the shell with TNT is helping out just as much as the man who puts that shell in the gun; in the same way, the man who helps build a tank or make its weapons is a fighter. We can feel pretty sure, I think, that in future warfare those fighters will not be spared. Even 25 years ago, warfare on industrial centers was being waged vigorously by airships and by airplane bombers.

Political and Population Centers.

The second reason for attacking cities is that they are centers of population or political centers. I think it is true to say that, particularly in democracies, every center of population is a political center. Attack on the enemy's political centers tends to break up the channels of communication within the enemy's government. The more bombs you can drop on the enemy's war department, navy department, state department, and economic bureaus, the more harm you will do him on a big and far-reaching scale; and the more you can inspire the enemy's population to bring pressure on its own government to end the war, the more you help your side.

Examples of Attack on the Two Types of Cities.

The town of *Coventry* is a recent example of the industrial target. The "pulverization" of Coventry has become a byword for complete destruction from the air. Near Coventry is the famous Austin Motor Works, which not only produces automotive vehicles for the British Government but probably has been producing airplane engines and parts. Coventry, therefore, is no doubt an important industrial link in the production of war machines for the British, and it is easy to see why Germany destroyed it.

The attack on *Liverpool* is a similar example. Liverpool was not the actual source of industrial production. The production, in general, came from the United States, but the idea is the same. In the case of Coventry, the enemy presumably tried to destroy at the source both war machines and the workers who made them. The attacks on Liverpool attempted to destroy materials en route from

factories in the United States, or to prevent their being landed.

Regarding war from the air on political and population centers, the attack on *Rotterdam* of a little more than a year ago stands out as an example of destruction for moral effect. The war was moving very rapidly in the Netherlands at the time and could have been expected to pass far beyond Holland before any considerable amount of materials could have been produced in Rotterdam. About 1 square mile in the heart of Rotterdam was claimed to have been thoroughly devastated within a few minutes. That is an example of an attack on a population center. One might think that the Germans would have blasted The Hague, which is the capital; but that is a relatively small city and was therefore a less effective place to strike.

There is a more recent example—the attack on *Belgrade* in Yugoslavia. To invade Greece, the German Army had to get through Yugoslavia and eliminate resistance there as quickly as possible. According to newspaper reports, they destroyed a large section of Belgrade in a very short time.

The attacks on *London* which have been going on for so long may have seemed to you to be attacks on a political center or on a large industrial city—perhaps a combination of both.

Facts About Bombing.

I will give you some general facts about actual bombing. Bombs are dropped from special airplanes called bombers, for the purpose of damaging ground targets. There are three kinds of bombers—heavy, medium, and light. In

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general, the bombers used for attacking cities are heavy or medium bombers, and there will be night bombers. An Air Corps officer, recently returned from England as attaché and observer, told me that day bombing of well-defended localities is obsolete—at least for the time being. Future developments may change this. In day bombing the number of airplanes shot down is too great. The fact that bombers are now forced to use darkness for attacking defended localities changes the picture of the defense set-up in which you are primarily interested.

Incendiary and High Explosive Bombs.

There are two kinds of bombs: Incendiary bombs and high-explosive bombs. Incendiaries are mostly small, averaging between 2 and 4½ pounds in weight. There have been occasional reports of the Germans' using special types of incendiary bombs; for example, oil drums with bursters which scatter the oil and ignite it when the bomb hits. These are apparently experimental, and the standard type of incendiary is the small, magnesium-filled kind.

High-explosive bombs for use on cities will weigh in general not less than 100 pounds. The more bombing goes on, the more we see how necessary it is to use the biggest bombs possible. It is true that a rather small bomb, if dropped on a vital part of a building, may do a tremendous amount of damage. If it does not hit the right place, it does not do any great harm. For example, bombs falling slantwise frequently pass out through a side wall and explode on a vacant lot. To prevent such failures, bombers are making extensive use of bigger bombs. Nothing less than 500-pound bombs are considered satisfactory for use against modern buildings, at the present time, and there

seems to be a trend toward the use of much bigger bombs—as large as 2,000 pounds. Larger ones have been used to some extent.

Instantaneous and Delay Fuses.

There are two types of fuses—instantaneous and delay—for use in bombs. The short-delay fuse has as its principal objective the hitting of lower floors of buildings. In the case of low-flying airplanes, it permits the airplane to get out of danger before the explosion occurs. The short-delay fuse is not of primary interest to you.

The long-delay fuse is the type that concerns you. Fuses are available now that can be timed to explode 24 hours or even longer after the bombs are dropped. They can cause a great deal of trouble. If the enemy is dropping time bombs along with short-delay bombs, and a bomb does not go off, the people on the ground do not know whether it is a dud or a long-delay bomb and they have to be careful about approaching it. If it happens to drop near a factory, work is likely to be stopped while bomb experts are finding out whether it is a long-delay bomb. Factory production is curtailed not only by bombs which destroy the factory but also as a result of the demoralizing effect on the morale of the workers. For example, records from the First World War show that production fell off badly for as long as 24 hours after a bombing raid and the "All clear" had sounded.

The fact that day bombing is "out" as far as well-defended localities are concerned introduces complications for both attackers and defenders. The first thing a country does when it expects to be bombed is to black out

its cities and make the entire countryside as dark as possible, thereby making it difficult for the enemy pilot to find his way. A few scattered lights on the ground will not help the navigation much. Lighted cities, towns, and large bodies of water help navigation. For example, a pilot takes off from an airdrome, such as Chicago. An area is chosen within a radius of 100 miles of his home airdrome—a section with only small villages in it—and he is assigned the job of navigating his way to one of those villages on a moonless night. The pilot is going to have an extremely difficult time finding the right village even with lights on. If all the lights are out and the weather bad, it becomes almost impossible.

This difficulty of night navigation is shown by some raids on England made by German zeppelins in the First World War. About 50 big zeppelin airships were used, each of which could carry a couple of tons of bombs. The zeppelins had a good many advantages over airplanes in regard to navigation. They were equipped with radio-compass and carried crews of about 25 men who could watch the ground for landmarks much more effectively than one pilot in an airplane. However, we happened to know where they went on almost every raid they made, because the British maintained a very elaborate system for spotting the course of those airships. By reports of agents, and from German radio messages, the British usually were able to identify the airship and even to know what its German serial number was. After the war, access was had to German reports which show where the Germans thought those airships went and where they thought the bombs landed. In 1915 the bombs fell, on the average, about 25 miles from where the Germans in-

tended them to fall. In 1916 the bombs fell about 16 miles from where the Germans thought they would fall.

Radio Beams and Area Bombing.

Since the last war, in order to overcome such difficulties, the Germans have introduced a new expedient which seems to be effective even when the ceiling is zero—the use of radio beams for bombing. By means of this radio beam a pilot can navigate safely in the roughest weather. In effect, it is a beam about half a mile wide. It travels in a straight line. The pilot can guide himself along the right edge, or along the left edge, or in the middle of the beam by means of radio signals. If there were an intersecting beam so that the pilot could know not only when he was flying along a line but when he got to a point near a particular objective, he could drop bombs blind and have a pretty good chance of scoring a hit. As an example, the Germans are reported to have one beam station in France and another in Norway. These two beams intersect at the correct point for dropping bombs on London. The pilots release the bombs and make a hit without ever having seen the target.

However, that is not precision bombing but area bombing. Beams fluctuate a little bit. Factors like that cause the results to be inaccurate, but the beam is a means whereby areas can be found and the vicinity of the target bombed when the ground is completely invisible.

Precision Bombing.

We have not placed much faith in area bombing in this country because we have more confidence in the possibili-

ties of precision bombing by the use of the bomb sight. Some other countries have believed that precision bombing by airplanes is most difficult. Instead, they have used a great number of bombs to plaster the entire area. We admit that even with a good bomb sight many bombs will miss. The gist of the matter is this: A lot of bombs aimed at specific targets are going to land elsewhere whether the method is precision bombing or area bombing. They are going to land in residential districts, and that is going to give people with jobs like yours a lot of work to do. The worst danger areas in which to live when an enemy is bombing are portions of the city which lie near a factory district, and areas which show many lights, such as blast furnaces or places where blackout precautions have not been properly enforced.

It is my belief that modern incendiary bombs have a hazard for our American cities which is likely to be one of the most serious difficulties of passive defense. In this country, wood is used for house construction to an enormous extent, even in closely built suburbs of cities. That is not true in Europe. There, the average small house, whether in city, suburbs, or country, is of masonry and consequently rather fireproof. I believe that statistics fully show our peacetime fire hazards as relatively far greater; and that even in our cities with their strict building codes, much larger fire departments have been found necessary than abroad. Unless adequate preparation is made for fire control, it seems likely that the use of incendiaries against this country would have consequences far greater than those now being observed from their use in Europe.

Q. What is the minimum or maximum amount of elevation for the dropping of incendiary bombs?

A. Incendiaries can be dropped from almost any altitude. If you drop *high explosive* bombs with instantaneous fuses from any lower altitude than 450 feet, you are almost sure to get pieces through your own airplane. *Incendiary* bombs, however, do not throw fragments so they can be dropped from as low as 100 feet.

Q. Would the critical area depend on the height of the airplane?

A. Yes; our bombing tables show that the inaccuracies of the bombing increase directly with the altitude. For example, in a ship without a bomb sight, a test showed that bombs dropped from about 750 feet hit a big field 4,000 feet long and 1,400 feet wide; they also hit at 2,000 feet altitude. At 2,500 feet and above, the field could not be hit reliably. It was guesswork bombing. With the bomb sight, of course the accuracy becomes much greater, but the principle is the same. You may have to drop as many as 93 bombs to get one direct hit on a small target from a high altitude.

Q. Does the air pressure or friction of the bomb coming through the air have any effect on the material of which the bomb is made?

A. The air pressure has no effect at all. It does affect the ballistics of the bomb and hence influences the curves as the bomb falls through the air. All that is worked out in advance by the ordnance department, which has as part of its job the business of testing all new types of bombs and determining just what allowance to make.

Q. Would you consider that the black-out is the one best defense against air raids?

A. No; the one best defense against air raids is the pursuit airplanes. The proportion of night bombers brought down by pursuit airplanes is becoming greater and greater.

The barrage balloon is a small, sausage-shaped balloon which is an interesting means of defense and must have some value or it would not be used to such an extent. It works like this: Cables are suspended from the balloon and act as a net for airplanes. Once ensnared in these cables, the plane is rendered useless.

A similar device is reported to be used for protecting ships; it consists of two parachutes connected by a cable. They are discharged by a mortar and float down separated. An airplane may run into the cable, and in some cases the propeller is stopped by the cable which is wound around its shaft.

The most impressive means of defense against bombers is antiaircraft artillery, which includes the little "pom pom" guns, about 37-mm. down to 20-mm., and machine guns for low altitude bombers. These guns bring down more airplanes than they used to.

Q. How close would you consider that a 500-pound bomb would have to come to a building in our city for a near hit?

A. A 500-pound bomb striking near a building of steel and concrete will not do much more than blow out the windows and shake down the fixtures, especially if it lands more than 30 feet away. One crater I saw made from a 500-pound bomb was about 15 feet wide and 6 feet deep. A brick building located about 150 feet away was entirely undamaged.

It might be well to point out that the defense of cities by antiaircraft artillery, while it has great advantages, also gives people charged with protection of the civilian population something to think about. During the First World War, antiaircraft artillery often was not provided with high explosive shell, but rather with shrapnel. The shrapnell shell is, in effect, like a small cannon flying through the air. Its base and sides are made of thick material, and when the charge goes off it blows out shrapnel bullets with a shotgun effect. The base and the sides of the shell fall intact. I believe there were nearly as many people killed by the shrapnel cases of their own friendly artillery in the last war as were killed by the enemy's bombs.

Q. How many 500-pound bombs can a plane carry?

A. It depends on the size of the airplane and the bomb-rack design. An average bomber will carry four to six bombs of that weight, as well as others.

Q. What method of passive defense is the best?

A. A combination of all of them. I think you have to use all the means that are known.

Q. Has antiaircraft artillery any value?

A. By means of machine guns, it does great damage to low-flying airplanes. The medium-size "pom pom" guns are dangerous, and the high altitude antiaircraft guns not only are dangerous but also have a very disturbing effect on the enemy bombers.

Q. What is the most distant range of antiaircraft?

A. Modern guns can shoot as high as airplanes can fly. Antiaircraft fire at very high altitudes is not actually very dangerous to the airplane. It may disturb the enemy bombers but it will not bring down a large proportion of airplanes if at more than 17,500 feet at night.

Q. Would it be feasible, during a black-out, to have a glare of light in an isolated spot 20 to 25 miles from a city?

A. The enemy might become suspicious and learn to use the light to help navigation. If it were done carefully it might be of value. Dummy airdromes are used to decoy the pilot so that he will drop his bombs in the wrong place.

Q. What area does shrapnel shell cover?

A. Let's get this straight. On the ground is a gun which is shooting a shell at an airplane. In the last war the shell was often a shrapnel shell which discharged bullets in a sheath or cone. In that manner they attempted to bring down an airplane. The shell case itself, however, fell intact and it was likely to fall and often did fall on the city which was being defended. The high-explosive shell used now breaks into small pieces but these are still often heavy enough to injure individuals.

Q. There has been a lot of talk about black-outs. What about a tremendous amount of light in cities instead of black-outs? Would not that be just as confusing?

A. I have read an account of your suggestion. It seems that the main problem of the enemy is the difficulty of navigating to the designated objective, and if you turn a flood of light on the cities you would accomplish precisely what you want to prevent. The pilot would be able to find his way. For example, if the whole city of New York were brightly lighted it would still be possible for the enemy to aim his bomb in the middle of that glare of light. On the other hand, would it be possible for you to cover the State of New York? I think that the amount of electricity would run into astronomical figures, and the amount of copper wire required to cover even one State would be more than this country would produce in many years.

Q. How about searchlights being set up?

A. The same thing seems to me to be true in this case. If you are going to mislead the enemy as to where the city is you'd have to put searchlights all over the State and the equipment required would be prohibitive.

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ACTIVE DEFENSE AND PASSIVE DEFENSE

By
Lt. Col. George J. B. Fisher, C. W. S.

There are many things about the manner in which wars are fought today that we dislike very much. One of them is the ruthless bombing of open cities with the resultant killing of civilians. That sort of thing doesn't set well with the professional soldier who is bred to Anglo-Saxon ideals of warfare. It is certainly contrary to the aims and wishes of the American Government, and it is looked upon with loathing and disgust by the American people.

However, we do not propose to waste our time bemoaning the fact that war today is not conducted as we should like. Distasteful as the facts are, we must face them and meet them with courage if we are to survive. If we are drawn into this war, we must be prepared—and well prepared—by mastering the special techniques of defending our cities against aerial attack.

The defense of modern cities against bombing attack includes two distinct modes of action. The first is active defense; the second, passive defense.

We shall examine now these two types of defense so that each of us may clearly understand how they are integrated and how each complements the other. In this course we are concerned primarily with passive defense, yet we must realize that passive defense is the second line of defense and that it comes into action only after the first line of military defense has been penetrated.

A Backward Glance.

Before examining the important features of active and passive defense, it may be interesting to glance backward in order to appreciate more clearly how these two techniques of defense fit into the perspective of military history.

The attack of cities has always been to a large extent the objective of military action.

To defend centers of population and industry from being pillaged and destroyed by invading armies, fortifications were devised in the shape of walls that encircled every important metropolis of antiquity. When the wall fell the city capitulated. When the wall could not be breached, the attackers settled down to siege operations and waited patiently, sometimes for a year, until starvation forced the inhabitants to surrender.

Much ingenuity was exercised to speed the operation of breaking down the circling walls of ancient cities. Some of the first applications of chemical warfare were tried out for this purpose.

The mechanical catapult, which had been used with varied success up until the fourteenth century, was replaced about this time by artillery.

Here we witness a radical change in military strategy brought about by a fundamental innovation in military weapons.

The first important use of artillery in siege operations occurred in the year 1331. It was the Germans who first employed this weapon, using it in attacking Italian cities.

The earliest siege weapon was a heavy mortar called a "bombard," a term that in the ensuing centuries has acquired a sinister meaning.

Once means had been devised and perfected for shattering the walls of cities, this form of defense became obsolete. To prevent the attacker from dropping his projectiles on the city itself and thus smothering it in ruins, it became necessary to organize an army and send it out to meet the approaching enemy at a distance beyond the range of his artillery.

This then became the essence of military strategy for the next six centuries—to meet the attacker and destroy him before he could reach and destroy the city. This gave a special significance to military maneuver, so that much of military history from the fourteenth century down to very recent times is a record of one army attacking and another army defending a city, even though both armies might maneuver at considerable distances from the actual cities they were attacking or defending.

You will recall that the operations of the two principal armies in the American Civil War were based almost entirely on the effort of the Army of the Potomac to capture Richmond and the effort of Lee's Army of Northern Virginia to capture Washington. When at long last Lee's army could no longer protect Richmond, the war was over.

In the First World War we see this same general motive behind the effort of Germany's armies of the west to capture Paris, and the failure of this effort marked the First Battle of the Marne as one of the important turning points of that war.

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The Airplane Changes Warfare.

However, the First World War completed a full cycle in the history of military strategy, for it was the last war in which a field army could successfully defend a city by merely holding an enemy force at bay. The airplane, which entered the picture during this war for the first time, changed all that.

The airplane afforded a weapon with which military commanders could reach over and far behind defending armies to strike directly at those very cities which defending armies were attempting to protect. In doing so, it forced changes in the military art that were as radical and as far reaching as those that followed the introduction of artillery weapons in the fourteenth century and, because of the tempo at which we live today, these changes were brought about very much faster.

The airplanes that were standard in 1917 were mere fledglings compared to the fearsome instruments of aerial destruction that have since been developed. The typical World War airplane carried a load of about half a ton. Its cruising radius was only 3 or 4 hundred miles. Its speed was not more than 100 miles per hour. Today a military airplane that travels less than 300 miles per hour is considered a liability in battle. Modern aircraft are capable of cruising continuously for thousands of miles, carrying munition loads of as much as 5 tons. These facts explain why it is possible for modern air power to reach far into the interior of an enemy country and there wreak havoc and destruction at almost any point it elects.

This fact, while it certainly does not render field armies useless, at the same time does force changes in military strategy and does force the adoption of entirely new measures for the protection of cities against military assault.

In order to simplify this discussion, I shall hold closely to the central idea of the defense of cities. We all realize, of course, that there is much more to military combat, aerial combat, and naval action than the mere protection of centers of civilian population and of industrial production. Foot soldiers and airmen and sailors all exist primarily to seek out the enemy and destroy him wherever he is. Yet the fact remains that in war today the enemy is very likely to be found somewhere on his way to strike at cities, at airplane factories, at anything the destruction of which he thinks will weaken our ability to fight.

The first step in forestalling this type of aerial invasion is obviously to strike down and immobilize the enemy's air power. The farther this can be done from our own shores, the better are our chances of escaping the effects of aerial invasion. A great deal of nonsense has been written during recent years by people who have been violently opposed to our engaging in military operations beyond the sight of our own coast lines. That short-sighted policy certainly never found any support among people who understood the implications of aerial strategy.

If we cannot keep invading aircraft beyond our own horizons, then we must maintain control of the air over our own national territory. Control of the air means that we must be able to intercept and fight it out with invading aircraft before it reaches its target—usually the populous city or

important industrial facility which it is attempting to destroy.

Purpose of Aircraft Warning Service.

In order to do this, we must first have timely warning of the approach of enemy aircraft. For this purpose an aircraft warning net is set up, consisting of innumerable sentries stationed at lonely listening posts on the fringes of our territory and at sea. These sentries, watching continually by day and night, flash the warning of approaching danger—by telephone or radio—to what is known as a "filter center" or a central point into which may come the reports of several hundred individual watchers.

The filter center is thus enabled to plot the course of the approaching enemy and to relay this information to the information center under which it operates.

The aircraft warning net with its filter center and information center are installations under control of the United States Army Air Force. There are four air force commands within the territorial limits of the United States.

The information center to which warning of approaching aircraft has been transmitted has now to take some very quick and vitally important action.

In the first place, it must notify the intercepter commander of the location, speed, and direction of the approaching enemy aircraft in order that fighter planes may take off instantly and engage the enemy as far as possible from his objective.

At the same time, other elements of the active defense that may be needed for military action are likewise advised. For example, the appropriate antiaircraft artillery com-

manders are warned and balloon barrages are placed in position. When the attack is coming at night, necessary black-outs are ordered. These are all features of active defense and all function under control of the local air force commander, who is responsible for the principal or aerial defense and who must therefore control the secondary or auxiliary *military* defense.

In the present stage of the development of aerial warfare, however, it is not humanly possible for this military defense to prevent in every instance all the elements of the hostile fleet from breaking through and reaching its target.

We can realize to some extent why this is so by remembering how difficult it is to see even in broad daylight an airplane flying at an altitude of 20,000 feet. Not only can an approaching airplane escape our vision but by shutting off its motors and gliding down from high altitudes it can avoid being picked up by our most acute listening apparatus.

We will concede, then, that it is necessary to warn all cities and important industrial facilities in the path of approaching aircraft of the impending danger in order that measures of passive defense may be put into effect.

Where Passive Defense Begins.

Anyone who has studied closely the effectiveness of aerial attack against European cities in the present war must be struck by the fact that the curve of this effectiveness rises sharply at first; then levels off; and finally begins to drop off sharply. What causes this drop is the fact that measures of passive defense, when finally per-

fected, do counteract very materially the destruction of life and property resulting from aerial bombardment.

It is our good fortune in the United States that time has worked in our favor in this connection. By taking advantage of the tragic experience of the British in withstanding aerial assault, we should be able to level off the curve of attack effectiveness at the very start instead of suffering severely as the British did before we work out out passive defense arrangements and put them into effect.

We now have, I hope, a clear idea of what is meant by active defense—those things for which the armed forces are responsible: First using the Army, Navy, and air force to hold the enemy as far from our shores as possible; and, when an aerial attack is on the way, to determine its direction and probable target, then bring into action our own fighter planes, darken the enemy's path, ready our antiaircraft defense and antiparachute forces, and finally alert our cities to the impending attack. Now let us look more closely at what the city itself must do to lessen its danger.

The best place to start consideration of passive defense measures is when warning of the approach of hostile aircraft is given by the military authorities. Active defense measures preceding this point are responsibilities of the Army, particularly the Army Air Corps. Once the warning is given, however, it is the properly constituted civilian authorities who must put into effect appropriate passive defense measures.

Let us first consider the warning as it is turned over to civil authority by the military.

To illustrate how this works it may simplify the problem to consider for a moment the warning service worked out

by the Chinese to protect their inland capital at Chungking.

Chungking is an extremely inaccessible point in the interior of China. When the Japanese set out to raid this city, they must travel a distance of several hundred miles over an area which offers no attractive targets for bombing attack. Therefore when Japanese planes are seen heading out on a bombardment mission in the general direction of Chungking, there is no question whatever in the minds of the Chinese warning net operators where they are going. Not only is the objective clear, but the Chinese are able to predict with accuracy when the bombs will begin to fall on Chungking and to predict this from 1 to 2 hours in advance.

It is a simple matter to telephone or radio the warning to the Chinese military and civil authorities at the capital and to afford ample time for even a leisurely evacuation of the city. On receipt of this warning, the Chinese therefore take refuge in caves that have been excavated in nearby cliffs so that the loss of life from the repeated bombings of Chungking has been reduced to practically nothing as a result of this warning service, even though the property damage is sometimes considerable.

Now let us see how different this problem is when applied to the continental limits of the United States.

An Assumed Case in the United States.

Let us assume, for instance, that a hostile air force is reported by observers stationed on the northeastern tip of Maine. This force is seen approaching from the direction of Newfoundland and heading generally toward New England. It is quite impossible to determine from this information which of a thousand cities, towns, or important

industrial facilities scattered from Boston to New York City might be the object of the coming attack.

However, as the enemy approaches and his path is quickly and clearly plotted, it may be possible to form a definite idea of his objective within a space of minutes. So as the flight progresses it becomes possible to give an alert or stand-by warning, what might be called a "probability of attack" warning. This preliminary warning justifies the initiation of certain general defense measures, such as the assembly of auxiliary police, fire, and medical units, in appropriate cities, towns, and isolated industrial facilities.

The final type of warning to be given by the military authorities is an "all-out alert," under which everyone in the area most likely to suffer attack is notified. Please note at this point that the military does not notify the man on the street, but notifies the appropriate civilian authorities, who in turn, according to the prearranged air raid precaution measures in vogue in that locality, spread the warning by means of sirens, whistles, telephone, radio, and other means of communication.

All this happens at rapid speed. The enemy air fleet is traveling, let us say, at a speed of 300 to 400 miles per hour. That means that the enemy will travel from the frontier of northeastern Maine all the way to New York City in no more than an hour and a half. The warning net system must work quickly and accurately, remembering always that needless alarm should not be given, but that at the same time as much advance notice as possible must be given in the area where the blow will fall; and, of course, that an "all-clear" signal will be flashed as soon as the danger has passed.

The military authorities, as everyone realizes, have a big job in handling the aircraft warning service. We can believe that the job will be done, and we are not going to spend any more time in this course considering that particular phase of the problem.

The civilian agencies must undertake at this point an equally important and in some ways more complicated job of actually carrying into effect prearranged measures of passive defense.

Courage and Competence Are Needed.

This work must be done with courage and competence. Let me emphasize those two C's: Courage and Competence. The courage we know our populace possesses. But courage alone is not enough, and even this can be quickly vitiated unless we know what we are doing and are competent to do in an expeditious manner the things that must be done.

And let me say right here that our passive defense measures will, for the most part, be carried out under the handicap of darkness, with every vestige of artificial light that may help to guide an enemy aviator blotted out. Day attacks come only in modern aerial warfare when the defender has lost control of the air—which we are confident will never occur in the territory we are studying. The only real chance an enemy has of breaking through our own intercepter air force is at night, and, although this imposes the greatest handicap in carrying out our civilian air raid precaution measures, we must have clearly in mind the need of being prepared to conduct this work in

inky darkness, except for such illumination as might follow the firing by incendiaries of our own warehouses and factories.

Our problem, then, is this: What must be done when the air raid siren sounds at night?

One of the first things, of course, is to call to stations those active groups who will cooperate with the city's permanent public safety agencies, such as—

Air raid wardens.
Auxiliary police.
Auxiliary fire fighters.
Decontamination squads.
Medical and first-aid groups.

Next—or even simultaneously—the general public must be warned, down to the last man, woman, and child, to take shelter.

Then—during the raid and even for some time after the raid—the situation calls for disciplined control all along the line while steps are taken to counteract the effects of a rain of high explosive and incendiary bombs and poison gas, any or all of which may be loosed simultaneously.

In other words, when the air raid warning is received the passive defense PLAN is put into operation—a plan so complete and far-reaching as to cover, in some degree at least, the activity of every inhabitant in the city. For everyone is either actively employed in some feature of the passive defense program, or else must conform with the city's passive defense regulations while the raid is in progress.

All this involves planning, organization, and training—a great deal of each.

The more this problem is studied, the more obvious is the need for the perfection of a coordinated, smooth-working scheme of action that can be put into effect at a moment's notice when warning is received of an impending attack.

Planning Is the Keynote of Passive Defense.

So the keystone of passive defense is a PLAN: First a master plan developed by the State defense council; then county and municipal plans coordinated with this master plan; and such subordinate plans as may be necessary to the defense of isolated industrial units.

This planning for passive defense—and the organization and operation under these plans—are all aspects of the protection of civilian life and property which under the American form of government are functions of local civilian authority. The Federal Government can and will advise on technical features of passive defense, but it does not propose to usurp from local government its responsibilities in this field.

One of the methods of cooperating with local government in this direction is the conducting of schools such as this, where knowledge may be imparted concerning special techniques with which the Army is quite familiar: Protection against war gases; the handling of incendiary and explosives bombs; and medical aid.

Certain civilian groups must master these special techniques. Not only must they be able to apply them when necessary, but also be able to instruct others—active and

inactive participants in the local air raid defense program.

We do not cover, by any means, all aspects of passive defense in this course. All we can hope to do is to give you a good foundation in some of the most important technical features of passive defense. If we succeed in that, then each one of you, when you return home, will be enabled by your specialized knowledge to take an important part in carrying out some feature of your local defense plan.

ORGANIZATION AND CONDUCT OF LOCAL SCHOOLS

Presented Without Editing. Use as a Guide to Training, Not as a Lecture

During the half period we had before lunch, the experiment we tried with the magnesium ribbon chips was not very successful. I think one reason is that with magnesium chips there is a much larger piece of material to burn. There is very little surface exposed, per unit of weight, and it is quite oxidized on the surface.

Let us now use magnesium ribbon. The idea, you recall, is to use it as a means to simulate an incendiary bomb. These incendiary bombs cost a lot of money and when you are instructing and working with firemen you probably won't have bombs to set off for them. There will probably be men in your class who will perhaps have to be convinced that metal can burn. The point is that you can pass around the bits of metal to them.

It is a good idea to have a blow torch handy in case the thing doesn't go off; experiments which fail to function as intended are very embarrassing to the instructor. I think this will light up without a great deal of trouble. Just place a piece of paper underneath to show how the incendiary action can be carried along to combustible material.

A Cheap Substitute for Bombs.

You are not throwing away money on this experiment. You can buy this ribbon in any chemical supply house for

a few cents, or get it from the science department of any high school or college. Try to get magnesium ribbon. It comes in spools, and the cost is very little. For 25 cents you should get enough for several demonstrations. Tell the people whom you are training to train others to use substitutes as training aids if they can't get what they want. Remember we talked this morning about CN and the using of sulphur and other materials as substitutes.

Advanced Gas Training.

Supposing that conditions were serious enough to warrant training men in the use of lethal gases such as chlorine. In time of war this procedure probably will be authorized. In time of peace it is frowned upon, for general use, because of the danger involved. I believe you people went through chlorine chamber here at the school. You might get in trouble if you were to use chlorine at home without proper authorization. If it is authorized you should have a chlorine container available. You would have this chlorine in a liquid form under pressure, and you could release a certain amount of it as needed.

However, chlorine is very easily made on a laboratory scale sufficient for a gas chamber. Take muriatic acid (dilute hydrochloric acid) and add it slowly to crystals of potassium permanganate. It is a good reaction to remember, although I am not trying to make chemists out of you. Take an ordinary empty tin can and put an handful of crystals of potassium permanganate in the bottom of the can. You can experiment to get the right concentration. Then add slowly a small quantity of muriatic acid—approximately a tablespoonful. (Naturally you are

wearing a gas mask during this time.) That will give you a good concentration for a chamber of ordinary size.

Remember, before you use chlorine, check with proper authorities to find out if it is permissible to use. It should be used only in advanced training.

Smoke Training.

In the way of other devices which we have had passed on to us by people out "in the field" who are working in chemical warfare, there has been recommended for use an oil can smoke pot as an expedient. Probably you won't work with smoke a great deal, but you may have occasion to do so in your training. If you can't get HC smoke pots, the ordinary type of smoke pots normally used in training, you might be able to make some if they were needed for a demonstration.

If you want to make a smoke screen, take an ordinary 5-gallon oil can. Enlarge the opening at the top to hand size, and provide a makeshift lid of wood or metal. In this 5-gallon can cut slits or draft holes about 3 inches above the bottom of the can and about 1 inch by 3 inches on each side. Now above the draft holes take some heavy wire and weave it across each way to form a grate. Illustration was drawn on blackboard. Lace it around like weaving a basket.

You can make one for an experiment and you probably can improve on this design. We have here a cross-sectional view; it looks something like this. You build a fire on that little mesh of wire with small oil-soaked shavings or chips. Then add wet grass, straw, or hay and you will find that you have a surprising amount of smoke com-

ing out. One man must attend a battery of three or four of them, but it has worked out pretty well as an expedient, or substitute device.

It may also be used for simulating a gas attack in place of the CN grenade or candle. Troops marching along can be surprised with an attack of gas; have two or three men standing with lighted pots ready when the troops come along, then put sulphur in the hole on top of the burning fuel. If you pack earth, wet straw, or wet grass around these draft holes you can regulate the draft.

The sulphur will burn to sulphur dioxide or sulphur gas. This will cause the men to put on their masks and gives you a chance to test their gas discipline. This is a very cheap device. Perhaps you may use it in your civilian defense classes. Normally, whenever you are going to work a problem like this, try and get CN grenades.

Blasting Machine Substitute.

Another thing which has been employed as an expedient is the use of batteries in place of an exploder box. In operations using detonators and squibs, we normally set them off by an exploder box or, as it is often called, a blasting machine. We have found that the radio B battery of 22½ volts and the so-called "Hot-Shot" (three dry cells) battery both work very well in firing four or five detonators or squibs. Detonators and squibs, you will recall, require the same amount of current to be set off.

When connecting batteries for this purpose, make connections to the detonators in parallel and not in series. Probably you are all familiar with the parallel and series connections. A parallel circuit, you will remember, is a

divided circuit. In a parallel connection wires lead off individually from each unit to be fired in this fashion (indicating on blackboard), joining on to the common lead wires. See that each one joins on to the proper wire. This is the parallel, and this is the series connection (indicating on blackboard). In the case of batteries, always use the parallel connection and in case of an exploder box use the series. There is a reason for it, but it involves mathematics beyond the scope of this course.

Another idea which has been used successfully is that of showing the effect of DM, DA, and CN in the classroom. We couldn't get away with it here. Suppose we were to set up a concentration of CN, DM, or DA and have a fan blow it out to the audience. It wouldn't go over very well with other occupants of the building, especially as regards DM and DA, which are quite toxic. However, if you have a limited time and want to show the men the effects of CN before they go into the gas chamber, you might, in your classroom, be able to give it to them in weak concentrations.

You might be able to work with this device: It is about 4 inches high and is a sort of miner's lamp. Just take an ordinary metal screen wire, curl it around like this (indicating on blackboard), and make a cylinder out of it. Then take a whiskey bottle cap and stick it in each end. One whiskey bottle cap will serve as a base for a candle and the other as a generation point for CN or whatever else you may be using to generate gas. The candle flame will heat the top. Put in the top cap a little capsule or a few crystals of whatever chemical you are using, and show the effect of it. You might be able to use such an experiment at the end of a period. It would at least work out

quite effectively in clearing the room promptly; it would serve as a sort of grand climax.

Testing Gas Mask Discipline.

Let us suppose we are testing gas discipline during a time when all citizens have been warned to wear gas masks. We could make a spot check on a main street as follows (blackboard illustration): Fasten some wire screening over the exhaust pipe of an automobile with a piece of hay wire, or by some similar means. Take a small amount of CN—say a few tablespoons—and put it into the exhaust pipe of the vehicle. When the motor heats up, and exhaust fumes are expelled, CN gas will pass off. It might be a device you could use effectively for training purposes, not only with the ordinary citizen but with your firemen.

I am bringing up these things because it is possible that they may suggest to you other devices that you can use in connection with your civilian defense classes.

Other Training Expedients.

Suppose that rescue work, traffic control, and similar activities were being simulated as if they were taking place after an air attack. Smoke from burning material would undoubtedly be a deterrent factor in this work. How can we introduce smoke into the situation? How about fastening four HC smoke pots on the ends of pieces of two by four extending out from the rear of a truck? (Blackboard illustration.) The forward motion of the truck at 5 miles per hour will cover a front of over 800 yards in 4 or 5 minutes. Of course firemen don't have to be cautioned to employ a safety man in the truck with a good supply of sand or water.

Maybe you will say that some of these devices I have discussed don't have particular application to your situation. If you have used other devices which you find work out well, let us know about them—write to the school. We shall pass on all useful ideas to others.

Training Instructors.

So much for substitute devices. We are going to discuss for a while the organization of the schools in its broad aspects. When you go back to your organizations, you are probably going back to train men to do this instruction work.

In the Army we consider that to be the first phase of our three-phase training. The first phase we consider as instructor training. Part of the first phase is carried out here at the Edgewood Arsenal at the present time. We are training a nucleus of instructors and they in turn are going out to train more instructors.

The second phase as we consider it in the Army is the basic training of organizations.

The third phase is the one Colonel Fisher emphasized this morning—the trying out of basic training results under simulated combat conditions, simulating actual situations which might be met, let us say, in an incendiary attack. We call that stage tactical phase—tactical training of organizations.

The way it is done in the Army is to make certain that the officers train the noncommissioned officers. In turn, the officers supervise basic training given by the noncommissioned officers to the troops with the rifle and machine gun. Then we actually get out "in the field," and, under conditions simulating actual warfare, we work out the

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tactical matters which apply to the work. That is the general policy we try to follow.

Decentralized Training.

Another point we emphasize particularly in the Army (and the Army has had a lot of experience with training) is that in training we make an attempt to decentralize as much as possible. By decentralizing we mean not trying to do the work all by yourself. You should train other people to help you out—at least, that is the fundamental idea. That is not a very elaborate definition, but definitions, in my opinion, are slippery things; understanding is of more importance.

We might decentralize in this manner—squad leaders (corporals and sergeants) train men in the use of the rifle and the gas mask. The company commander doesn't give all the instructions; he has a lot of other work to do. We decentralize instruction down to the platoons, and the platoons decentralize down to squads. We may have a corporal instructing 8 or 10 men.

Sometimes we have individual instruction under this decentralized idea. Sometimes the squad leaders are not as good as some of the available instructors. Nevertheless, the sacrifice in good instruction is overbalanced by the fact that the individual soldier can learn much more if he is in a smaller group, can ask questions more freely, and has a chance to see the thing demonstrated to him.

Progressive Training.

Another thing emphasized in the Army is progressive training. By progressive training is meant simply, not starting in the middle. You will notice that people who

have had training in a particular subject sometimes have a tendency to assume that other people know a lot more than they really do about the subject at hand. They don't start at the beginning. They start in the middle without carefully linking up with what the individual already knows. The training, therefore, is not progressive.

Proceed from the simple to the complex. Don't start in the middle and then have to go back to the beginning and reorient the student. It is a poor procedure and may disgust, discourage, or thoroughly confuse the student. Try to make your training progressive. Start at the very fundamentals.

Applicatory Method.

The third point that is emphasized is the applicatory method. In the applicatory method we try the procedure out under simulated war conditions, or simulated fire fighting conditions, making the situation as realistic as is possible with reasonable precautions as to safety of men and material.

The Training Mission.

The reason we train men in the Army is for effectiveness in war, and the reason you are to train men in this work is for effectiveness in passive defense. This might be construed as effectiveness in war also. So much for fundamental policies.

The Lesson Plan.

The point I want to emphasize in connection with the lesson sheet issued to you is the lesson plan. The lesson plan is a particularly important thing, inasmuch as you

may be instructing today in a certain subject and something else tomorrow. This is especially true in our work.

We make notes on these lessons (lesson plans), leaving them for the assistance of the person who is to carry on.

You should have a plan for each individual lesson as a guide in "putting it over." If you have your notes and material, and plan it in a logical order, it works out much better. You may lay your notes aside when you start your teaching job, but nevertheless the logical plan has been formulated in your mind.

A particularly effective device is the planning of your lectures in such a way as to have the group ask questions and discuss answers. That stimulates interest in the group. The lessons should follow each other in progressive order, so that if you are not there to teach, the person who substitutes for you will know where to start.

Four Steps of Lesson Procedure.

In your schools you should insist on the instructor knowing the four steps of lesson procedure. The four-step plan is like a football play. In any teaching job—in the classroom or in the field—regardless of whether or not it is a manual job, these four steps should be followed: Preparation, presentation, application, and testing.

The preparation step we consider as preparation of the student's mind for the job. We may do it by questions, or we may do it by anecdotes of one kind or another. For example a colonel in the Cavalry is talking to the Infantry officers. He wants to sell them on the idea of the importance of the Cavalry. Let us consider as a situation that these men are somewhat prejudiced against the Cavalry. What the colonel is trying to do is get their confidence and cooperation before he gets into the subject.

An Example of Preparation.

He may start off something like this: "Last night I was lying in bed, and since it was very warm I had removed my pajamas. Suddenly a mosquito went into a power dive directly for my ear! I had no sooner brushed him off than he attacked my flank. It seemed that there were a lot of mosquitoes around, but I couldn't make up my mind whether there was only one very active mosquito, or a number of them. They (or it) kept bothering me so much that finally I had to get up and walk around the room. I was very uncomfortable and couldn't accomplish my mission—that is, to get a good night's sleep.

"The mosquito in this case represents the Cavalry. The Infantry is represented by the relatively herculean creature—the man. What does this little mosquito have? It has mobility, fire power, and shock. That, gentlemen, is the reason for having Cavalry. It moves in fast with a lot of fire power to shock a particular point." That is a pretty good preparation stop.

I know of a particular instructor who was starting a class in metal forging with a group of college engineering students. On this particular day, he told them they were going into the laboratory and warned them to be careful, citing previous accidents and emphasizing that he didn't want to have any "horse play." He further told them to use tongs whenever picking up metal, regardless of whether or not they believed it to be hot. The general rule is: "All metal is hot" (writing on blackboard). The students went to the laboratory and found pans containing a piece of steel on each bench. Several immediately handled the steel which had been heated for this purpose. Burns resulted. That was a particularly drastic preparation

step, but at least he put his point across. The idea was to indoctrinate the class in obeying rules and regulations. I understand that particular class did pretty well.

Preparation and Application.

In the presentation step we should consider carefully the various methods. Use that which you believe to be the best. It may be that lecture-demonstration will be the most suitable, or perhaps illustration will work best for a particular situation.

Now as to the application step. Let them try it if possible, and then correct them whenever they do something wrong: "Don't you think it would be better if you did it this way?" or "Try this" should be stock expressions.

Test by Doing.

When you are satisfied that they can do the job, apply the fourth step—testing. The students are to be on their own. "Do it without any help," you may say. In this way you can ascertain whether or not your students can do the job. If a student has trouble, talk with him, and see what his trouble is. A critique (or critical discussion) should always follow the testing step.

Try always to have a preparation step. If you tell an ancedote or funny story that has something to do with the subject that you are teaching, it is a good device, but don't tell a story just for the sake of telling a story. Don't tell a story unless it links with your subject. Use common sense. Don't read off a lecture as I did this morning in our experiment with the paper cups—try to *show* them if you can. Let the students try to do it if you can, at least give them a chance to talk about it. Test them and then talk over mistakes. That is ideal teaching procedure.

LONDON UNDER ATTACK

General Avery. I will take this occasion to introduce these two speakers. Chief Deasy, and Chief Officer Ivall, Deasy of New York, and Ivall of London.

Chief Deasy. General Avery, officers, and members of the post, I will try to tell you what they do in planning protection in England.

Protection of Factories.

For safety's sake, factories are divided into two classes—those that are manufacturing war essentials, and those engaged in the manufacture of nonwar esentials.

Each factory has a man on the roof in a sand bag enclosure.

Of course, I don't need to tell you what that sand bag enclosure is for. You know. Now on the receipt of an air raid warning, the man in the nonessential factory transmits a local alarm throughout the building and workers all proceed to the shelters.

Where they are manufacturing war essentials, it is different. If those men quit every time they had an air raid, they wouldn't produce much; so they wait until they hear the scream of the bomb, then they dive into an open place built on the floor 8 feet long and open at both ends. They go in, one on top of the other, helter skelter.

Roof Patrol.

On the roof, if the roof isn't built equivalent of 4 inches of concrete, they try to keep 4 inches of sand. It is placed

so it will not run down into the drain pipes. They keep it above the roof, 6 inches or so, and they put down a layer of chicken wire. Then they cover it with tin, and that holds the sand.

That man on the roof takes care of all small incendiaries. The fire department isn't called unless absolutely necessary. It is best to keep two men on the roof at all times as company for each other.

On that roof are a stirrup pump to handle the small incendiaries, and shovels and rakes.

As you go through the building, you see that wide floor areas are subdivided so that in case an incendiary drops through the building, it won't sweep the entire floor. All windows are covered so that no ray of light can be seen outside after black-out. The factory has its own local fire alarm on all floors and its own fire-fighting forces. They take care of all conditions.

On the lower floors, the first and second floors, it is necessary to protect the windows. Glass fragments have caused a lot of misery in England, and a lot of times they are fatal, so you have to protect those walls and windows; they protect your personnel.

Multiple Power Feed.

If the plant is fed by power lines, and most plants are, it is advisable to feed the power into the plant three different ways. If you feed it in one way, a bomb might rupture that one feed, and you would have to shut down until it is repaired. The same is true of telegraph and all communications. Bring them in more than one way. Feed them through three different lines, through three different

streets and routes, so if a bomb does damage to one, you can use the others. In that way you won't slow up your production.

Black-out.

Some people ask me how it looks in a black-out. The only place you have lights is where one light burns on each corner. They have about a five-candle power bulb which can be seen about 50 feet in the air. They have a bell reflector over that, of an opaque material, to diffuse the light.

All the buildings are darkened. You can't see a light there. If you had a light on, you would be imprisoned. A policeman would come almost immediately, and no questions would be asked, and no excuses are accepted.

Automobiles are kept off the streets during black-outs. The only exceptions are fire trucks, rescue trucks, ambulance cars, army equipment, and such apparatus. These automobiles have a very dim light. You can see that auto from 10 to 20 feet away; that is all. I know because I stood in the street and had one run at me, and before I jumped I figured it was far away. There is no light that can be seen more than 300 feet in the air. They don't leave that to guesswork. They send up planes and they test for that. There is your city in a black-out. It all seemed mighty black to me, and it is. They have a number of automobile accidents. Traffic conditions are bad. To help to a great extent, we over here recommend luminous paint on the curb so that all pedestrians and chauffeurs will know where the curb is, so they won't get tangled. When that happens we all know who loses.

Now during an air raid, you will hear the sirens, and the bells clanging, and then you hear a different kind of a scream. They don't tell you what it is. You know, and you try to put your head in like a turtle. You wish that you were a million miles away.

Land Mines.

Now a lot of people want to know what kind of bombs they use over there. First comes a nice little thing they call a Land Mine. That is borrowed from naval warfare. They weigh from 1,200 to 2,200 pounds. They come down in a parachute 37 feet in diameter. They are held in place by four silken cords. The parachute has been identified definitely as the property of Japan. The parachute is thrown down, and it comes down pretty slowly, and it floats to the ground. When the mine goes off, you think all Hell is let loose. Following the terrific blast, a frightful suction takes place, seeming to prove that the blast created a vacuum. Autopsies on men who had been in this suction area showed that the lungs had been thrown up in the necks, and the men died. That land mine is not a nice thing to play with.

When the police department locate these things and they are duds and don't go off, they rope off the streets, put up red signs, and evacuate for 8 hundred yards' radius—that is, they rope off nearly a square mile. That is a big territory to evacuate. They know if there is a fire in that neighborhood, the fire department can't bring their pumps closer than within 200 yards of the land mine because the vibration and pulsation through the ground is liable to agitate that mine and set it off. That is how dangerous it

is. The suction will take it out 100 yards on this side, and throw it over 100 yards on the other side. Well, that is the land mine, and the English say that whoever invented that was related to the devil.

Delayed Action or Contact Bombs.

They have delayed action or contact bombs. The delayed action bombs are timed from one-tenth of a second to 7 days. You can figure out what disruption they will do. They are used in all sizes, and they will tear the guts out of everything. Their 25- and 50-pound bombs seem to be like our old Mills hand grenades that we used during the last war. The more pieces, the more materials are liable to be crippled, and the more men are liable to be put out of action. So they work on the same theory—the more pieces from the 50-pound bomb, the more fragments, and the higher the death rate. They used them on workmen in Coventry, and it goes to prove you don't have to knock down a factory. If you kill the workmen, it is more effective because if just the factory is knocked down the workers can be sent to the next town to work, but if the workman is killed that is the end.

The land mine in itself does not create fire. It will rupture piping, strip electric wiring, blow down buildings helter skelter, and thus cause fire.

Fire does more destruction than all the bombs ever dropped.

Aerial Bomb.

Now they have another thing that is a distinctly incendiary product, and they call it the oil bomb.

These have from 18 to 52 pounds of crank case oil taken from the crank case of an airplane motor. They cork it, bottle it up, and catch. But you don't want to be there when it comes down. You can figure for yourself what that thing coming down from 20,000 feet can do. It will be traveling at a high velocity. Let it crash through the floor of a building, and you have 25 or 50 gallons of oil burning around. What chance have you got to put this thing out? You would use what you would in most cases, and that is water. If you have a hose, use it, and that is fine. Let me tell you something, you have a real scrap on your hands to try to save the building, and you are lucky if you do. If there is a combustible thing there, you can imagine what would happen.

When those bombs hit in the street, they are liable to blow the gas main, and it will throw burning oil all around the buildings. If that happens, you use the phone and get the authorities, but leave the gas main alone. Your gas main is creating an explosive, and somebody's head is going to be carried off.

For firemen, particularly, I might say that you don't put out fires by putting your men there. There was never a general who lost his army and won a battle. It is useless to send a man out to do a certain job, through a spirit of bravery, when he is sure to be killed, and perhaps be the cause of 200 other men being killed. You are going to find such things happen. You see it happen now sometimes. You have to use your head in these things. Being brave and getting killed is not going to help anybody. That bomb is going to cause fire because it bears peroxide and it will go off.

"Pearl Necklace" Bomb.

Now they have another thing over there which they call the Pearl Necklace. It is a delayed-action bomb. There are a number of smaller bombs around it. It comes down in the street and sinks down. Those small bombs go off, and then you have concussion, vibration, and shock; all the small bombs are wired to the big one.

Now they have a gang there called a bomb-removal squad. I call them the suicide squad. They are. It is their duty to go down and excavate. If the heart of the bomb is still beating, they get out of the way. If they are not careful, they may create a slight shock or do something else to set the thing off. These smaller bombs will set off the larger one, and that's that. The Pearl Necklaces don't start fires themselves by the same means as the other bombs, but they may create fire.

"Molotov Bread Basket."

Then they have the Molotov Bread Basket. It is an incendiary bomb carrier. It holds from 36 to 50 small bombs. When it opens the small bombs are thrown out. They start fires, and they cover a large area, so that you might have 50 fires at the same time. One plane can carry about 2,000 of them. Now when you hear them coming down, and around, you think a fellow was just shoveling those things out, and I guess that is what they do. They really do cause fires. They carry so many of them in a plane, and the planes can come over in relays and keep dumping them. If you haven't your roofs protected, you're bound to have fires.

Now the only way to put them out is by spreading sand on them, so they won't burn through a floor and start a fire downstairs. In a park you might shovel dirt on them, but in a building you would have to use stirrup pumps or something similar. It has 30 feet of hose, and has a dual nozzle. It takes three men to operate it. The minimum amount of water to handle one of these conditions is 6½ gallons, if it is used right. For a fire department over here, I have an idea that our 7½-gallon pump, that is the Indian pump carried on our backs, would be better. It would take one man to operate, whereas it takes three of their men to operate the stirrup pump.

Some people say it is too much weight to carry around. I don't know. I think we might need that extra gallon, so I will stick to the 7½ gallons.

Mayor LaGuardia asked me what I want the extra gallon for. I said, "I don't want it, and the fellow who carries it won't want it, but he might find it offers a little more protection."

Dealing With Incendiaries.

Now don't get closer than 150 feet when those things are burning. If you leave them alone, they will burn for 15 minutes. They will burn for 2 or 3 minutes very violently; then an intense pressure is built up; it will throw magnesium for a distance of 30 feet. Over there they recommend a wet blanket to be placed over the arm so you can use your spray. The spray doesn't put out the fire. It accentuates and makes it burn faster. The spray is protecting the surrounding combustible articles. Your fire doesn't get a chance to start. Some say that the fire-

men should run up and throw a bucket of water on it. That would be the last bucket of water you would throw. When you throw that water, the bomb will explode and scatter molten magnesium.

Those things have been treated generally with contempt. They take them out in the streets. Well, the other fellow found out about that, so he put an explosive fuse down in front of the tail. The heat coming up from the bomb sets off the fuse with sufficient force to kill you if you are close enough. Well, that got people a little bit upset. They can't see whether this bomb has this little cap, because the light from the magnesium is blinding.

If you can get there in 2 minutes before it explodes, you can put it out. But, you can't wait 2 minutes if it goes into a building. In 2 minutes your building might be gone.

Most of the people, I understand, have the idea that most bombs that are released strike buildings. That is not true.

7 Percent Do Damage.

The average area in a city in the United States with buildings erected on it is approximately 16 to 17 percent. Now all things being equal, if we assume that it be 16 percent, then 84 percent of the bombs dropped are going to be misses. Oh, they do damage all right, but they are not hitting buildings. Of that 16 percent, 9 percent do a nominal amount of damage. It doesn't ruin the premises. The other 7 percent do what they are meant to do.

Chief Officer Ivall. Gentlemen, officers, my talk is of the organization of the London fire service as it is today, and of course it is mostly of interest to firemen, but I

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hope that you might be able to gain something from it.

When it was foreseen that, in the incendiary attack from the air, the fire brigades would have to deal with large numbers of similar fires, whereas it had been previously rare indeed to get more than a few large fires at the same time, some adjustments had to be made.

Accordingly in 1938 it was decided to make a great increase in the London fire brigade by forming an auxiliary fire service. Briefly, it had to be done at this time by expanding the London fire brigade of 3,000 personnel and 200 appliances to 10 times its size by the enrollment of large numbers of men and women auxiliaries, that is auxiliary fire brigades, and increasing the appliances from 200 to 2,000. We had to organize a system of mobile travel. We had to organize auxiliary fire stations, augment the telephonic communications, provide for water relay systems. London was surveyed, and disposition of personnel and appliances was planned according to the fire risk.

Training Auxiliaries.

The auxiliary brigades, when they were created, were trained at the fire stations. It is what you call over here the engine house. They attended fires when they were free from their business. Sometimes they came in the afternoon. Mostly they came at night, and they were trained by picked fire instructors. Their period of training consisted of 60 hours. Then they had to pass their qualifying examinations, and they were allowed to attend the fire stations, and ride to special fires when they happened.

Well, we held dances and exercises to attain more volunteers. We had community exercises, mobility exercises from which we obtained the nucleus. We trained in moving apparatus from one side of London to another. The patrol system was organized. It was never actually put into effect. The idea was that the streets of London would be continually patrolled. They would have equipment, and a given crew of men with which to work. This was not so good, because we wanted to concentrate them in a given area. Instead of that we had a fire-alarm system which was operated, and we could look after any given place.

The auxiliary firemen had to be put in stations. This we did by requisitioning such things as schools, where you have a lot of space to house the tools, and the classrooms made ideal dormitories and mess rooms, etc. Where schools were not obtainable, we took larger garages or large premises. On the outskirts of London, we had to requisition private houses.

General Mobilization.

In September 1939, when we had general mobilization, these auxiliary forces reported to their various stations. All such things as cabs, stations, motor lorries, trucks, etc., had been steadily produced and stored up to that time where we could collect them and put them on the run at these auxiliary fire stations, and fire-alarm posts. Well, it was very hard work at that time as you can imagine to organize a force 10 times as large as the one we already had existing. A thing like that had never been done in any fire brigade, nor was it ever attempted before.

We have in the London fire brigade our own workshop; once a piece of material leaves a factory, it is never sent back for any kind of repairs. Even when such a thing as a chassis has been twisted, our men can put the thing together so that it will run. We get our men by requisitioning mechanics, they look out for our repair and equipment, and they take care of auxiliary vehicles in the London fire brigade.

We have our own clerical staff which has increased tremendously. It was necessary to assign clerical workers to the auxiliary fire stations, and they are important in the keeping of records of our work, and making things go along smoothly.

We have a record of the emergency water supplies which are very vital in fire fighting. All water stations were surveyed, and then the emergency water supplies were surveyed, such as the domestic tanks, wells, lakes, ponds, etc., and these were adopted for fire fighting use in case of breakage in the water mains due to enemy action. We had to secure suction pumps to get the water from these various places. If we wanted to get on top of a big building, we had to let down our pipe into this emergency supply and draw water from it by means of suction pumps.

We have a cross-index book which tells us where all of these emergency water supplies are located, and they give us the exact amount which is to be obtained from them. Those places that were small, we built 18-foot concrete walls around them so that we would increase the capacity materially, and once they were fixed we could use our suction pump. Now in London we have dams with a capacity of a thousand gallons of water. These are placed near big industrial buildings, and we use them for fires.

Water Supplies.

Where there was a lack of or shortage of emergency water, we put these dams in. We could always use these emergency dams, especially when the water mains were ruptured.

We had special pumps put underground, and we had them plainly marked so that we could get at them in a moment's notice.

The River Thames which runs through London was an excellent place for us to get water. We have posted heavy pumping units who are relaying water inland.

Now our forces in London are divided into 12 regions. Each regional commissioner is in charge not only of the fire-fighting forces in that region, but for any ordinary air raid protection in that area. We have a fire-brigade inspector who is appointed by the home office or the Government, and he looks out for the fire-fighting equipment, and the fire-fighting side of air raid precautions. We have 67 brigades in London, and 66 brigades outside of London.

(Referred to map.)

Now this represents London. This line here is the river Thames. On the north side, we have the northern division. On the south side, we have the southern division. Each division is divided into three districts. In the north we have the A, B, C districts. In the southern division we have the D, E, and F districts. Now cutting it down still further, there are an average of 10 fire stations in each district. You take the E district here, and there is much more room. They are of course divided according to the fire risk. In the central part of London the districts will be closer together.

District Organization.

Now this cross in the center is the superintendent or chief station of the district of which the superintendent resides, and he is responsible for all the personnel, equipment, and for the taking care of any and all fires that happen in that particular area of London. In the central part of London, we have the headquarters of the London fire brigade. These dots on the illustration will show the auxiliary fire stations. These boxes here represent the regular fire stations. As I told you, these auxiliary fire houses are schools, large garages, etc.

Now running through the center of London we have the river Thames which has been very good for supplying water. On this river Thames, we have fire boats which help out a great deal in taking care of any fires in the river or in the vicinity of the docks. These boats can be moved about as the emergency requires them to go wherever they are needed.

Each district has its auxiliary fire headquarters. We have telephone communication from the auxiliary stations to the regular fire stations. The fire stations are connected by direct telephone. We always get procedure reports by direct telephone.

Now we have the ARP which has such squads as the demolition squad, air rescue, the public unit service, gas, water, electricity, and so on. There is quite a lot of work to be done. During an emergency we have to get headquarters to get any of these squads who may be needed. There are calls coming in from all over London, and I think you can realize the amount of telephone work that goes on during an air raid. We have our own telephone

service unit men, and it may happen that a line will be knocked out of commission. These men will take care of it, and put it back in commission.

Heavily Bombed Sections.

Sometimes one section of London will be given a particularly heavy going over, while in other sections it is comparatively light. Then, this section that was heavily bombed must get in touch with headquarters, and ask for all the available men and equipment that they may need. The girl at one of the boards keeps check by means of pins stuck in the board of where the equipment is, and how much equipment is loaned by one company or section to fight fires. In that way, we know just how much equipment we have, and we know just how much each district has, and how much equipment has been borrowed by the different districts. If they need additional assistance, they call for it; and the necessary assistance is given until the situation has been taken care of satisfactorily. If further assistance is needed, the superintendent will call headquarters and report how many fires are in progress in that area, how many pumps he has available, how many men are in that area, and so forth. In this way we can keep control of the fires, and send and concentrate men and equipment where it is needed most.

I hope that you get some faint idea of it. I am just trying to give you a little picture of what happens during an air raid.

When the home office is notified of a fire, they immediately size up the situation and give the necessary orders to take care of the situation. It is the same as a general

in the army. He sizes up the situation, and then he shifts his troops accordingly. It is needless for me to tell you that the fire makes a good target for the Germans, and they will come back and drop bombs into the fire.

I want to tell you that it is pretty tough over there, and the people have guts, because I believe you could gather from Chief Deasy's speech what the people of England are going through at this time. The morale of the public is marvelous.

Don't think it is only the fire brigade that puts out fires. We have such people as air wardens, and demolition squads, and so forth, and the civilian population is helping out a great deal.

ORGANIZATION AND DUTIES OF RESCUE SQUADS

On July 17, 1941, a pamphlet entitled "Local Organization for Civilian Protection" was released from the national Office of Civilian Defense in Washington. The introductory paragraph is self-explanatory: "The Office of Civilian Defense has prepared a suggested civil defense ordinance and chart of organization made to fit the needs of the average city in the United States in the present emergency. This plan can be adapted to city, county, or other political subdivisions. It is possible to adjust the ordinance to meet existing State laws and charter restrictions or local conditions and necessities. In many instances passage of an ordinance will not be necessary."

Listed in the Office of Civilian Defense Functional Chart, "Suggested Local Civilian Defense Organization," October 1941, are the various functional departments under the Commander, Citizens' Defense Corps of a city. These departments, the heads of which will assist the Commander of the Citizens' Defense Corps, are: Fire, Police, Wardens, Emergency Medical Services, Public Works, and Utilities. All of these service and group organizations are vital to emergency defense operations; all of these groups must be carefully organized, trained, and their activities coordinated if effective results are to be obtained.

The chart, as listed, could be applied to a normal organization for a city of approximately 100,000. It could be readily expanded to care for the needs of a city of any size. For example: A city of 1,000,000 would have its Commander, Citizens' Defense Corps, with his staff (heads of various departments). There would be necessitated 10 Division Chiefs, each with his staff consisting of representatives from each of the six departments. Normally the Divisions will be subdivided into operating districts to care for populations of some 25,000. In each operating district will be the necessary depot, transportation, material, etc., to meet the needs of the operating squads.

The particular portion of this organization chart with which we are concerned during this period is that part pertaining to Rescue Squads which operate under the supervision and control of the Chief of the Fire Department, who in turn is directly responsible to the Commander of the Citizens' Defense Corps, and who will, normally, be located at the headquarters of the Commander. It is necessary to understand fully the organization chart in order that necessary cooperation and liaison may exist between Rescue squads and other squads, who will be at the scene of the incident, and who will be under direct control of other departments. For example, very close cooperation will be necessary with the Medical Corps, Demolition and Clearance Crews, Decontamination Corps and the Fire Service. While you gentlemen are interested primarily in the fire and police departments, as graduates of this school, you will be expected to be cognizant of the responsibilities of other services in order that interdepartmental cooperation may be realized.

An air raid upon a densely populated town may be expected to cause casualties and damage over a large area or areas. In the densely built-up areas of large cities, high explosive and incendiary bombs may be expected to cause widespread damage to buildings. Not only may the buildings be wholly or partly demolished, but frequently the occupants will be trapped and the adjoining streets blocked by the resulting debris. This situation is particularly true where many story masonry buildings are located close to the streets. High explosive bombs may also break power lines and rupture water and gas mains, thereby creating extra dangers to street traffic. When incendiary bombs are used, the outer walls of the buildings may be left standing with little support. Such walls constitute a serious hazard to traffic in adjoining streets which must be kept open. It is necessary, therefore, to brace the walls or to remove them entirely.

It is necessary to make provision on a considerable scale for the personnel required to deal with such a situation. Work of various kinds will be required and, in almost every case, speed will be an important factor.

In the case of damaged buildings, it may be necessary to rescue living persons entrapped in the debris, to recover the dead, and to take any immediate steps necessary to prevent further casualties or traffic obstruction from collapse of standing walls.

In normal times, duties such as these are generally performed by police and fire departments of cities. It has been an American custom for many years to call upon the fire department to handle any unusual situation such as rescuing the pet cat from a tree, releasing the youngster who has locked himself in the bath room or pumping water from a flooded basement.

For many years it has also been an American custom to depend entirely on the Army, Navy, and National Guard to take care of defense problems—not only during normal times, but when emergencies have arisen.

It has been indicated in previous lectures that modern war has brought with it the problem of aerial attack on cities and industrial centers. No longer may the inhabitants of such municipalities depend wholly on the fire and police departments or on the military forces to perform necessary emergency duties in their localities.

It follows logically, therefore, that the Civilian Defense Organization should take over such emergency duties with their various ramifications. Under the Civilian Defense plan of organization the specific problems of rescue and necessary debris clearance to accomplish rescue are assigned to Rescue Squads.

Various organizations in this country have been functioning efficiently for many years in handling problems of rescue in peacetime emergency situations. The United States Bureau of Mines has trained a group of some 25,000 men in rescue work. Although this organization has been primarily concerned with mine rescue, men trained by it are scattered over the entire nation, and should constitute a valuable addition to the Civilian Defense committee organization in our various cities. It is recommended that contact be made with these specially trained men.

Such existing organizations in this country, as well as defense organizations in Britain, appear to use the same basic organization for rescue squads. The set-up is as follows:

1. A central headquarters consisting of a Chief assisted by a staff and clerical force. The Chief directs the general

operation of the service and is responsible for the recruiting and training of its personnel. He functions under the direct supervision of the local defense coordinator through a control center and works in close collaboration with the chiefs of the other emergency services mentioned above.

2. The divisional headquarters consists of a superintendent, Control Center and staff at the headquarters of each division of the city—in larger cities generally corresponding to an area containing 100,000 population.

3. Central reserve depot conveniently located in each division and under the control of division headquarters. It is used for training and operation of *reserve* rescue squads and reserve personnel for replacing losses. A reserve of special equipment and supplies for rescue and debris clearance work is kept on hand at the central depot. The depot is in constant telephone communication with the service headquarters and dispatches *reserve* rescue squads to such places as they are needed, on direction from higher authority. Since such personnel may become contaminated by working in gassed areas, the central depot should be equipped with means for decontaminating personnel, clothing, and equipment. It also has normal accommodations for housing and messing the personnel assigned to the depot.

4. Four or more *operating* depots are located in each divisional area. The operating depot is the station at which the rescue squad is based and out of which it operates. This depot normally operates in area having approximately 25,000 population. Usually only 1 squad is accommodated at that depot. Instant response is made to any calls made on it by higher authority.

Rescue squads in England were formerly organized in two types: light and heavy. The light squad was intended

for immediate action while the heavy squad was to be held in reserve in depots to be dispatched to incidents wherein rescue operations were found to be extensive and difficult. The light squad consisted of a foreman and five men; the heavy consisted of a foreman and seven men. Each type squad was equipped with apparatus and appliances for clearing away debris and dealing with damaged buildings, such as ladders, chain tackles, sheer legs, hydraulic jacks, sledge hammers, crowbars, picks, and shovels. The heavy squad was equipped more extensively with heavy appliances which would include power driven appliances for moving heavy beams, concrete slabs, and other heavy objects, as well as equipment for cutting through steel and concrete.

Normally, densely populated and heavily built-up areas were provided with four light and two heavy rescue squads per hundred thousand population. In such cases two squads were normally held in reserve at the Division Depot.

Latest information from Great Britain indicates that the distinction between light and heavy squads has been abolished and that rescue squads now consist of 10 men with a driver, though in some cases the number is reduced to 8 or 9. They are provided with the necessary equipment for clearing debris, shoring, tunnelling, and so on, and each party has its own truck, and two-wheeled trailer and equipment as alloted it.

They are organized in depots in the same way as the First Aid Parties, and those are combined depots for First Aid Parties and Rescue Squads.

The Rescue Squads have the heaviest work of all to perform and their technique is being constantly improved. It has been found in practice much better to work them in

short shifts than to make them carry on for long periods. Continued operation after becoming tired results in excessive injuries due to carelessness resulting from exhaustion. Their work is not only often very dangerous but always very difficult.

The original composition of the latest type squads consisted of a skilled foreman, four skilled men and five unskilled men, all of whom were paid a salary commensurate with their rank. "Superman" characteristics are desired but not demanded of enrolled personnel. Men should be selected who have physical qualifications which will permit heavy and hard work for long hours, perhaps under the handicap of a gas mask or oxygen breathing apparatus, or work in atmospheres which may be low in oxygen or contain varying amounts of combustible or toxic gases. The work, too, requires the services of men who are skilled in handling mechanical equipment and who are familiar with house-wrecking work. Although robust, well trained engineers with practical experience are desired, it has been found that acceptable recruits may be found in the construction and building trades or from men who are experienced riggers and miners. Since much of the work of the rescue squads is a technique of its own and ideal personnel will be difficult to find, you, upon your return and subsequent organizations will have to search for men who are physically fit and then train them in the necessary techniques. All Rescue Squads are given elementary first aid training and also training in decontamination. Full complements of men for both active and reserve squads should be enrolled and trained before outbreak of an emergency requiring their services.

Rescue squads usually work in conjunction with first-aid parties, but the work of the two is separate and distinct.

Rescue squads are responsible for releasing persons entrapped in damaged buildings or debris. First-aid parties administer first-aid treatment to injured victims. Since rescue squads may have to work in gas concentrations or contaminated areas, they should receive antigas training and should be provided with masks and protective clothing. Although rescue squads do not perform decontamination work, they may have to deal with contaminated materials in rescuing persons and removing bodies from contaminated buildings. They should, therefore, know how to deal with such situations without injury to themselves.

Each rescue squad should have a large motortruck for transporting personnel and equipment for moving heavy debris or making necessary demolitions. In addition, it should have a two-wheeled trailer which can be dragged over fallen debris and torn-up streets.

The principal duty of rescue squads is the extrication of live persons and dead bodies from damaged buildings and fallen debris. In addition, necessary action regarding damaged buildings that are unsafe and require urgent attention may be required.

Since many of the persons entrapped in damaged buildings may be seriously injured, the work of extrication takes precedence over any other duties of a rescue squad and is started immediately upon arrival at the scene. Frequently this work involves: (1) Raising beams and floors; (2) cutting through steel and heavy concrete debris; (3) shoring up portions of structures in danger of further collapse; and (4) gaining access to rooms where stairs and corridors have been destroyed. Members of the rescue squad should avoid incautious actions which might cause additional casualties, either from the trapped civilians or members of the squad. When access to an injured person

has been gained and he is free to be moved, the rescue squad should not be responsible for moving him, providing stretcher parties are present. In the absence of Medical Corps personnel, however, rescue squads will be expected to administer first aid and to move casualties.

The next most urgent duty of rescue squads is to deal with buildings which, rendered unsafe by bomb damage, might collapse at any time. The Rescue Squad should perform this function only when the Demolition Corps is unavailable. Where tall unbraced walls are left standing close to a street or highway, the first step is to rope off and exclude the public from the danger area. The buildings or walls are then either shored up or demolished as rapidly as possible. Speed of action is important both from the necessity of public safety and to avoid unnecessary delay in access to public utilities where service must be restored to the public as soon as possible.

After the building is made safe, it is not the duty of rescue squads to carry out repair or restoration work, or to repair damaged streets or roads. However, it is vital to the public interest that all streets and roads be kept open to traffic, not only as a convenience, but to permit the movement of fire apparatus and ambulances. So far as it is consistent with rescue, work on debris or bomb craters or similar obstructions should be carefully supervised in order to clear the most important streets first. Major responsibility for this task, however, falls with the Demolition and Clearance Crews and Repair Squads.

Where damage to streets is accompanied by toxic gas contamination, decontamination squads should clear the area before rescue and repair squads go to work.

Rescue squads should not attempt to remove unexploded bombs. This procedure is very hazardous and requires

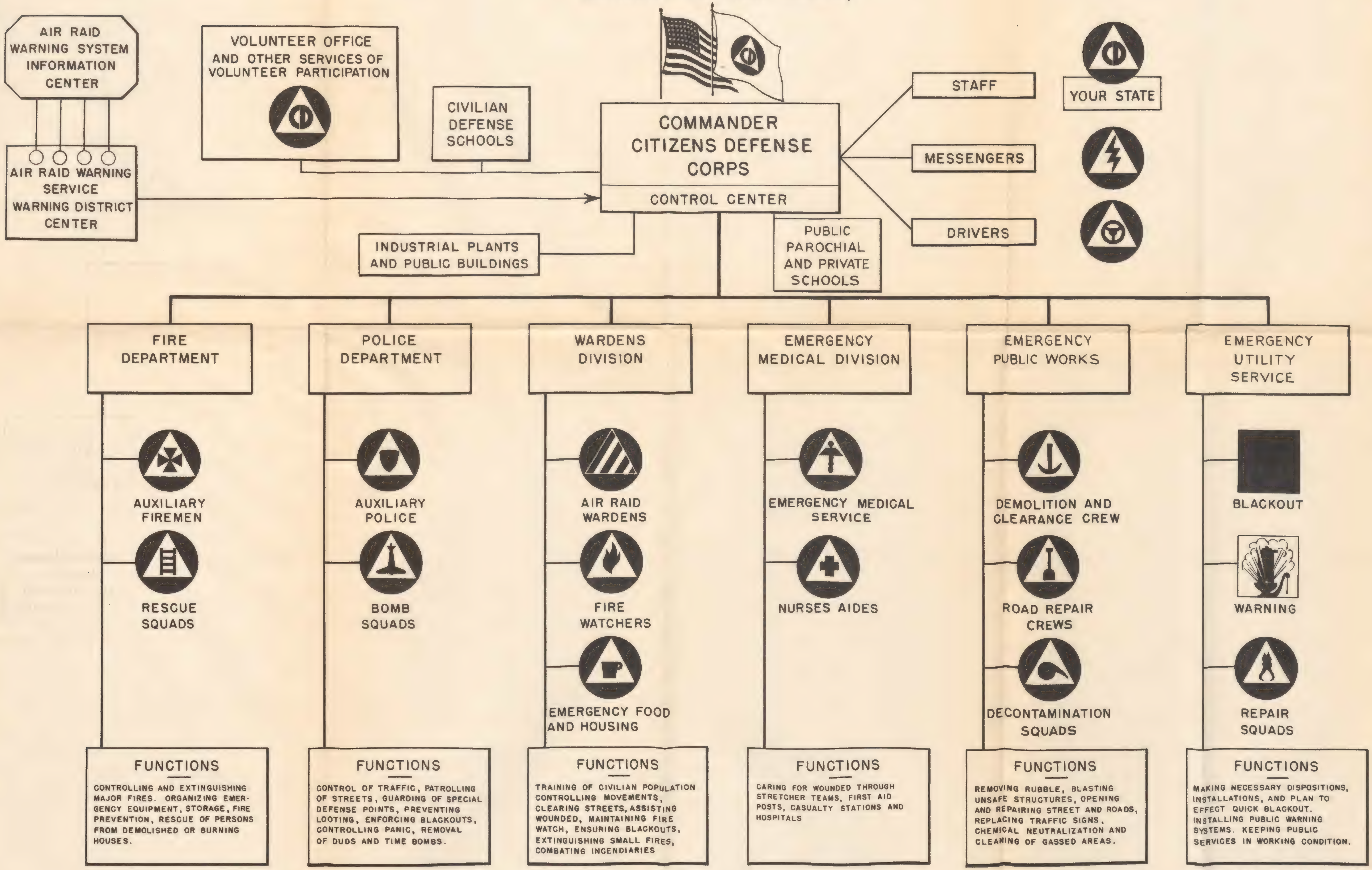
special military knowledge and skill. The Leader of a rescue squad should notify the police of the location of the bomb, rope off the danger area in the vicinity, and suspend further work in that area until the bomb is removed or exploded.

A well-organized and directed Rescue Service can do much to maintain the normal life of the community in the face of devastating air raids and can also materially reduce the number of casualties which would otherwise occur.

A suggested list of equipment for Rescue Squads may be found in the Handbook for Rescue Squads published by the Office of Civilian Defense.

CIVILIAN PROTECTION ORGANIZATION FOR A MUNICIPALITY

(CITIZEN'S DEFENSE CORPS)



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Standard School Lectures—
Civilian Protection
Series II

FIRE DEFENSE

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ABOUT THESE NOTES

These lecture notes, taken at the Civilian Defense School at Edgewood Arsenal, Md., are offered for the guidance of instructors in local schools. They are fairly complete transcriptions of the lectures as given, except that restricted or confidential matter has been eliminated, and the lectures have been somewhat shortened.

For the convenience of instructors, they are presented in series so that all pertinent material may be assembled in one place, together with any notes the instructor wishes to prepare himself.

Attention is called to Lecture on Organization and Conduct of Local Schools, in series I. This lecture deals especially with expedients and methods of dramatizing instruction; it is included here, not as the material for a lecture to be given by instructors, but for their reference in planning courses.

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IIA

NATIONAL DEFENSE ACTIVITIES IN FIRE DEPARTMENTS

By

Percy Bugbee

Major Brayton. We are receiving splendid cooperation from the different organizations and we are trying to tie in, as much as possible, all of the organizations that are playing an important part in this civilian defense program.

The National Fire Protection Association has been doing business for a good many years and Mr. Bugbee, its general manager, is in touch with civilian defense problems.

Mr. Bugbee. I will give you a running picture of the national fire-defense program as we see it. Our association, as many of you probably know, has the opportunity of obtaining a great deal of valuable information from fire departments throughout this country, and in fact, throughout the world.

First, I'd like to acquaint you men with our organization. The National Fire Protection Association was organized 46 years ago. It is a nonprofit engineering and educational society. We have about 6,000 members in 37 countries; about 1,200 to 1,500 of those members are fire department officers and men. We have State officials, building inspectors, fire-insurance men; we have a smattering of architects, building operators, librarians; in other words, a miscellaneous group of people who are interested in some phase of fire protection and control.

We operate our technical work through committees. We have 46 standing technical committees with a personnel of nearly 1,000 persons. They develop standards that are used as a basis of state legislation.

We also do a considerable amount of popular publication work. From our office during our past fiscal year ending May 1, we distributed 2½ million pieces of fire literature.

We have the opportunity, through our field staff, of visiting cities throughout the United States and Canada, and talking with fire-department authorities about their problems.

The fire-defense problem is too large to cover in a lecture. I am going to point out things we ought to consider in the development of this program that will have a lasting benefit—whether the emergency ever arrives or not, or whether the present world conflagration is over next week or 5 years from now.

Fire departments now have the opportunity to assume a constructive leadership of the entire civilian population. When you return to your own communities, remember that here is a golden opportunity for constructive service that will bring to your department respect, admiration, and the substantial support of the entire public of your city.

Problems Facing Fire Departments.

The fire-department situation in this country is very complex. We have nearly 15,000 organized fire departments in the United States, of which approximately 1,000 are paid and 14,000 are volunteer. There are many acute problems facing organized fire departments aside from

the setting up of auxiliary forces and the provision of auxiliary equipment. Too many of our fire departments are neither properly manned nor properly equipped to meet peacetime conditions. One of the first moves in any city is to increase the manpower and equipment of the fire department to a point which would be considered normal peacetime operating standards.

Effect of Selective Service.

There has been a lot of controversy and discussion about the draft and its effect upon our fire departments. We have talked with draft authorities in Washington, and you all appreciate the fact that it is entirely up to the local draft boards as to their attitude toward taking men from these individual departments. There is not and will not be any national ruling on the matter. I think it is clearly the duty of every fire chief to fight for the men in his department whom he wants to keep. I have talked to chiefs who feel quite strongly that they shouldn't make any attempt to keep their men. They claim that it is unpatriotic. I don't agree with that. A trained fireman is a very vital asset to this country, and it is a very foolish move to transfer those men out of the fire department into the military forces, thereby losing them from a service that is so important at this time.

Rather than spread apparatus or extend fire stations, particularly for the paid forces, it is vital that we build up the manpower of existing companies first. It is much more important to have properly manned companies and fewer of them, than to have more companies without sufficient manpower to operate the apparatus.

Training.

As to the problem of training the regular fireman, I don't need to dwell on that. All of you are familiar with training work and are probably concerned with it in your own communities.

Special Training.

There are certain elements of training that need special attention. The material that you are receiving in this school on gas and bombs is something that the average fire department man does not know about and has to be taught. However, it is essential that you shouldn't overlook the basic, fundamental day-to-day training that every fire department necessarily should give to its men. That sort of training must be continued.

I don't know whether or not you have had lectures in this course on the problem of fighting fires under black-out. The few cities in this country that have been experimenting with black-outs know what a problem it is. I talked with the authorities in——* where they are having regular weekly black-outs, and one of the most difficult problems they have to contend with is the problem of fire-fighting under black-out conditions. It is a problem that has had very little attention in this country, but one that I predict (if this emergency develops as it may) will require a great deal of serious thought and attention by you men.

Another form of training which has been overlooked to a considerable extent and yet is very vital under present conditions is the so-called refresher school for officers.

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*Name deleted for these notes.

Every city of any size should have an officers' college or conference, so that the officers can confer with the chief at periodic intervals and discuss their mutual problems. Relatively few departments do that sort of thing as a matter of course—all too few. It is an essential part of any training program. In building up the spirit and morale of the department, the officers of the department should not be neglected. The cities I know that have been holding officers' conferences consistently for years are cities that have efficient administration and organization. So I suggest to any of you who live in communities where they do not have a regular conference or college for the fire-department officers to consider the idea seriously.

Auxiliary Firemen.

The question of establishing and training auxiliary firemen is still a controversial one in this country. As you know, there are only a handful of fire departments in the United States that have established auxiliary fire forces. Undoubtedly, as this movement develops and the impact of Mayor LaGuardia's program makes itself felt, there will be a very considerable increase in auxiliary fire forces throughout the country. It goes without saying that that requires very careful study and organization.

The selection of the men to serve with these auxiliaries is important. It is not enough to take any volunteer who may present himself, to take the fire fans and the fellows who chase fire apparatus because they like excitement. They are not the type to be inducted into those auxiliary forces. They will have a bad effect upon the permanent men. They will be troublemakers in many cases, and the

possibility of friction and misunderstanding and the possibility of trouble with your permanent men is a very important one to be considered.

Mayor LaGuardia has sent out a statement about auxiliary fire services to the mayors of all principal cities in the country. His first recommendation in connection with this defense program is the immediate organization, training, and instruction of an auxiliary fire corps. He suggests that persons of military age, unless they have been or are likely to be rejected, should not be permitted to enroll; but that men of military age who have been physically rejected for military service but are capable of doing auxiliary fire fighting and other civilian defense work might well be used.

Enrollments should begin for this service in fire stations throughout all cities following the publication of a notice in the daily newspapers requesting volunteers to enroll. The call should be issued by the mayor. Time is the essence of success in organizing this necessary adjunct to the uniformed force. Those cities which have the manpower should use the city employees first. Every person having a physical and mental fitness to do the job correctly should be enrolled from the city forces. The advantage of the use of the city employees (where the manpower is available) as a bulwark of the civilian defense program can readily be seen; it provides a nucleus of persons who are already disciplined and coordinated under the municipal government.

Incidentally, that plan has been followed very closely in Canada. In all of their civilian defense work they have made the basis of their volunteers the civil-service employees of the provinces and cities. Nearly all of the aux-

iliary firemen and other auxiliary forces which have been organized in Canada today are drawn from civil-service employees of various municipalities.

Mayor LaGuardia makes these very pertinent recommendations to the mayors:

(1) Every city should have its full complement of paid fire department filled.

(2) A survey should be made of auxiliary pumping engines, hose, and equipment to determine the amount which would be required in the event of emergency.

(3) Cities should adopt proper ordinances (where necessary) for the creation of auxiliary corps as well as other civilian defense work.

(4) The mayors should contact the commanders of American Legion Posts, Veterans of Foreign Wars, and fraternal and civic clubs for the purpose of securing voluntary service for this emergency.

Several problems which may not have been clearly recognized and yet which must be considered as quite important are the problems of (1) the protection of these auxiliaries against injuries, (2) the provision of proper protective clothing for them, and (3) the provision of proper feeding of those men when they are, under an emergency, obliged to work for long periods of time.

Unless the equipment, food, and protection are provided for those men (and there are no immediate funds available in any city organization for that purpose at the present time) there are going to be a great many problems and difficulties, as there were in England when this auxiliary scheme was first started. Many of their problems were purely administrative rather than fire fighting problems—problems of providing food, equipment, and so on.

Auxiliary Fire Apparatus.

As to the question of providing auxiliary fire apparatus, Mayor LaGuardia has indicated that it is his thought that presumably the Federal Government will supply equipment when and where it appears to be necessary. The Office of Civilian Defense is preparing estimates of the amount of equipment needed to bring the fire departments of this country up to normal peacetime standards, and the amount of auxiliary equipment that may be needed to cope with the emergency.

There are elements of danger in the Federal Government's supplying cities with fire equipment and apparatus. You can all appreciate that. There is a possibility, unless the entire matter is carefully studied and handled, of political pressure being brought to bear in various cities to acquire more equipment than others. It is incumbent upon each city to develop a program of additional equipment of its own within the limits of its resources, and to depend upon Federal grants of money only for the strictly important equipment that may be needed in the emergency.

Need for Priority Rating for Apparatus.

There is, as you know, a very serious backlog of orders in the fire apparatus field today. The apparatus manufacturers cannot possibly fill the orders for peacetime requirements for some months to come. Thus far, the priorities board has not given recognition to fire apparatus, and it has been impossible for the apparatus companies to get the metals and material that they need to build appa-

ratus. We discussed this with the priorities board. We had a ruling from Doctor Hopkins, head of the metals division, to the effect that each case will have to be decided on its merits.

I referred that ruling and the entire situation to Mayor LaGuardia, and have an assurance from him that he is going to get a priority rating on fire apparatus, and get it immediately. I understand that in Washington a preliminary ruling has come out of the priorities board that plans fire and police equipment (along with a number of other equipments) on a special priority rating. So perhaps that hurdle has been overcome, and it may be possible henceforth to have apparatus made and delivered to our cities.

Standardization of Apparatus.

There is an obvious and important need for standardization of fire apparatus. We must avoid the special requirements that each individual fire chief thinks he should have. We have a committee on municipal fire apparatus, of which Chief J. N. Sullivan, of Utica, is chairman. We have a number of other competent fire chiefs serving on the committee. The committee has developed standards for fire apparatus of the common well-known types. The standards have been published and officially adopted, not only by our association but by the U. S. Conference of Mayors, and have been distributed to the purchasing agents of all the larger cities. We are hoping that these standards will be adopted as the standards for fire equipment in this emergency.

Emergency Equipment.

With respect to small emergency equipment, considerable difference of opinion has arisen in this country as to what are the best and most effective types of small auxiliary fire equipment. Because of the fact that in England they have been using trailer pumpers to a very large extent, many people have the idea that trailers are the one and only type of auxiliary equipment to use in this country.

Personally, I am not convinced of that. Trailer pumpers have some advantages. They also have disadvantages. One of these disadvantages is that I can see comparatively little use for that type of equipment after the emergency is over. If, however, we provide some form of truck with either a front-end or midship mounted pump of 500-gallon capacity; or a skid-load pump of the type which has been used so effectively in forest fire fighting (the men can take it off light trucks and carry it for considerable distances) and then standardize that type of equipment, I can see a very considerable value after the emergency in having that as extra equipment for fighting brush and grass fires. Brush fires are a troublesome problem in most of our cities. We have a report on trailer pumpers and specifications for auxiliary pumpers, which has been tentatively adopted and is now in print.

I heard one interesting observation about extra equipment and apparatus from District Chief Ivall, of London, who is now touring this country. He said that at no time in their emergency, even in the great raid on London of December 29 (about the most bitter fire raid that has ever been made over any city in the world at any time), had they ever been short of equipment or manpower to fight

fires; that they have never yet reached the limit of their resources. That is perhaps an indication that they are to some degree overequipped and overmanned in the auxiliary fire service in England, because at no time, in Chief Ivall's opinion, have they ever reached the point where they were in serious need of additional equipment or manpower.

Water Supply.

There are corollary problems in connection with this fire-department problem which I have been discussing. One of the most vital, and one to which you have probably given considerable attention in this course, is that of water supply. Preplanning, setting up emergency supplies in cisterns and in tanks, and charting possible sources of water in cities, such as the English fire departments carried out before the emergency arose, have proven of tremendous value in England. If any fire department has not as yet taken steps in cooperation with the city water department to find out what city water supplies are available, to make provisions for the pumpers being able to get down to streams, lakes, ponds, and other places where you might have to use the water, to study the special problem of laying long lines of hose for the relaying of water over long distances, and to study a cooperative scheme with the water department, I urge such action at once. It is a vital part of the problem.

One of the principal troubles in England has been the scarcity of water. In the case of a city like Coventry, which underwent a terrific raid one evening in which 30,000 homes were destroyed, the trouble was primarily not with the fire department or lack of manpower but with the lack of water.

Incidentally, about the clearest and simplest statement on the water supply problem is one made by Secretary Jordan of the American Water Works Association. It is called Public Water Supply in the Civil Defense Program. It was published in the American Water Works Journal for January and I recommend it to you—if you have not happened to see it—as a very good statement of the water supply problem in times of emergency.

Communications.

We have the vital and baffling problem of adequate communications. A fire-alarm system may be crippled or put out of service very early in a raid. You may not have adequate radio equipment to work with, and you may have to face a situation in which you have to depend upon runners or boy scouts on bicycles. It is important to develop two or three different means of communication to take care of any possible emergency.

Mutual Aid.

There has been a vast increase in interest in the subject of mutual aid between the fire departments in adjoining communities because of this defense program. In my own area around Boston there has been a very thorough and competent mutual-aid plan developed among a lot of the cities. Westchester County in New York is another place where they have developed mutual-aid plans. Most of that information has been published and is available. It is an interesting development in the face of the emergency.

Surveys Needed.

What should cities and fire departments be doing in these times not only to prevent fires that may occur from bombs but to prevent the all too many fires that are occurring in our big industries? New York City has made a very comprehensive survey of the city and every building in it, and has that information documented in complete fashion. Other cities have also done that. More should and will do it. Some of the States—like Maryland, Massachusetts, Indiana, and Michigan—have made State-wide surveys of fire apparatus and equipment from the total State point of view. Some cities keep card indices and records of every building in their cities with a plan of each building showing exits and particular hazards. That information is available to chiefs reporting to fires. If you have not done that in your city, now is the time to do it.

Fire Losses.

Every fire department in every city today should have a knowledge of the fire-fighting equipment that already exists in industrial plants, department stores, and other big buildings. If a private fire brigade has not been established in every important building in the city, the fire department should take steps to organize them.

The work being done by the inspectors of the fire-prevention divisions—the men who are inspecting in large fire departments—was never more important nor more vital to the defense program than it is now. We recently

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sent out a communication to the fire chiefs in all cities of 50,000 population and over in the United States, calling to their attention the fact that during the last few months there has been a very large number of heavy-loss fires affecting the defense program. I have a list of over 20 fires, ranging from $200,000 to $5,000,000 in losses that have occurred since January 1, 1941. The causes of these fires are as follows:

(1) An unreasonable concentration of combustibles.

(2) Fire fought by employees when the fire department should have been called.

(3) Lack of supervision of the building when it was under construction.

(4) Watchman given inadequate instruction in the importance of promptly calling the fire department.

(5) Valve supervision lacking or not properly carried out.

(6) Protective features, such as fire walls and sprinklers, removed from the building.

(7) An unusual concentration of especially valuable and damageable stock.

(8) Large areas, so that a large loss, once a fire was started, was practically inevitable.

(9) Protection of special hazards in the plant badly handled.

(10) Water supply not designed to fit the fire danger.

(11) Important structures given inadequate fire safety consideration.

(12) The management unconvinced of the need of, and unsympathetic to, fire protection.

That list is typical of the sort of things that are causing the huge losses we have had—and will continue to have

unless we take more specific, immediate, and direct action to concentrate on these important industrial processes and buildings, and see that they are given adequate attention.

Special Protection for Large Concentrations of Materials.

We have compiled a list of occupancies which we think require special treatment to prevent wartime fires. This list includes all important industrial concerns, piers and wharves, warehouses, large mercantiles, electric light and power stations, gas works, lumber yards, sawmills, and oil refining and storage plants. We have distributed to chiefs in all our larger cities a suggested report form to be used in making inspections of these large and important target hazards.

We ask that the reporting officer, whether he be a battalion chief or inspector, should make a confidential report—daily in some cases, and weekly in others—to the chief on the conditions that he finds in any particular plant. That would include comments on the plant protection, and would show when the last visit was made; whether he has made a spot-check of the important hazards; what he has found out about the private fire brigade and watchman service, supervision of valves, attitude of management, any new or unusual concentration of stock or finished goods. A simple form that is designed specifically to meet an emergency situation such as we now face.

The Federal Government is now purchasing and bringing into this country a very large quantity of essential commodities—rubber, wool, nitrate of soda, and many others. This material is being dumped on piers in various parts of the country. It seemed to us important that some plan

be set up to notify the local fire departments that this material was being brought into their cities. We have set up a plan, through the National Bureau for Industrial Protection in Washington, to check with the various defense commodities corporations. We compile data on these supplies and materials coming into this country and the amounts and places where they are to be stored. We pass that information immediately along to the fire chief in that community. We tell him not only what has been imported, but what is expected to come in to his city. We ask him to take prompt steps to inspect it, and to see if the building is adequate and proper.

The National Board of Fire Underwriters in New York get similar information, and they relay it to the rating bureau in the state where the material is coming in. Thus the insurance inspectors can ascertain where this concentration of value is and inspect it.

In that way we are going to save some bad fires in these large concentrations of materials. In the last war there were a number of such fires, mainly due to the fact that the fire departments had not been advised and could therefore not take the necessary steps.

Inspection of Homes.

While I am talking about the importance of inspection in these times, let me make just a brief observation of the fact that we have been hammering away on the importance and value of inspecting homes. If there was ever a time when home inspection was valuable, it is now, and if there was ever a time when you could expect the cooperation of every home owner, it would be now. Today there are two

or three hundred cities in which men go out and make a semiannual or annual inspection and investigate for fire hazards in every home in that city.

Those of you who are here from such cities as Providence and Worcester know the effectiveness of home-inspection work. It has cut the number of fires and loss in dwellings from 75 percent to 50 percent with no extra cost to the city, no extraordinary or undue burden on the property owner, and with a corollary and very important increase in the respect and admiration of the community for the fire department for undertaking that extra burden of work. Such work has a profound effect when the Fire Chief goes before his Council to get appropriations for the next year.

The fire department in the city of Cleveland, Ohio, is undertaking a very elaborate campaign to organize and train private fire brigades in every important building in Cleveland. They have concentrated their defense efforts on that particular phase—on the theory that that was more immediately important than possible attacks by bombs. That seems to have aroused a great deal of interest among the industrial plants and mercantiles in Cleveland, and it seems to be a great success.

Fire Protection for Defense Industries.

The protection of essential defense industries in this country is, to a considerable extent, under the supervision of the Federal Bureau of Investigation. To assist the F. B. I., the National Bureau for Industrial Protection has been established in Washington by the insurance companies. This makes available some 6,000 insurance inspectors to visit industrial plants, and to see that proper recommendations are made.

It is of unusual importance right now that every large fire and, if possible, every fire in every community, be thoroughly investigated. Some of you have been carrying on careful and adequate investigations of fires for years. These investigations are essential, not only because the information you gather is of value to the training school and to the officers' school, but because it has a vital effect in suppressing arson. It is an important deterrent not only to saboteurs and arsonists, but to the man that is apt to be careless. If fires are carefully investigated and it is known that they are, and if anything is brought out in the courts or in public to the detriment of owners of such properties, it has a valuable effect as the actual apprehension of possible incendiarists.

Fire Prevention Ordinances.

One thing—perhaps a little prosaic but important and desirable at this time—is the opportunity to get more adequate fire-prevention legislation adopted by city councils. City officials today are receptive to any ordinance proposed that will help the defense program. Now is an excellent time to get the adoption of fire-prevention codes, to be administered by fire departments. These codes should be entirely separate from the city building code, not covering construction features but hazards such as the storage of oil and other combustibles. Such matters can be covered in fire-prevention codes such as you have in many of the important cities today like Seattle, Los Angeles, and Richmond. Now is a good time, if you have not up-to-date or comprehensive ordinance, to revise it and have it accepted.

Coordination of Fire Defense With Other Civilian Defense Activities.

Mayor LaGuardia has made a very clear statement about the proper coordination of this entire program, including the specific responsibilities with which you are not concerned—such as the air raid wardens, the rescue parties, the decontamination squads, the bomb squads, the ambulance squads, and the gas and electric squads. The coordination of the fire-fighting and fire-defense plan with those other related agencies presented a difficult problem in many cities. There may be overlapping; there is bound to be confusion to some extent as to the differentiation of duties between the police department and the fire department, and as to where some of these other services enter the picture.

The fire department, as long as the Mayor has given the fire departments the initial leadership in getting these auxiliary forces under way, should take the initiative in seeing that these other services which will follow the fire service are so organized that they will coordinate and cooperate with the fire service rather than cause confusion and trouble.

Publications on Fire Defense.

Here are a few of the reference books and pamphlets that appeal to me as the most desirable. You may be familiar with some of them.

Our association has published a general manual on fire defense, which has been rather widely distributed as a textbook, and is used in many of the air raid schools as well as in the fire schools. We have the trailer pumper report

that I spoke of earlier in my talk; and a little pamphlet called "Fire Defense Programs, Suggestions for Defense Councils and Committees."

The pamphlet, "Defense Programs for the Fire Department," by Chief Palmer, recently published by the International Association of Fire Chiefs, is an intelligent presentation of the problem that the fire departments are facing.

Three excellent books written by the Civilian Defense Committee of Ontario have had rather wide distribution in this country. Handbook No. 1 is an organization and instruction manual, setting up the entire civilian defense plan for the province. The second one is a general training manual. The third is a fire service manual. This is the one which would most interest you. These can be secured from Mr. W. J. Scott, the Provincial Fire Marshal of Ontario, at Toronto. I know he has been very generous in making those Canadian pamphlets widely available to fire departments and others in this country.

I hope I have not covered too wide a variety of subjects, but I was anxious to include something about all these things in which I am so interested and concerned.

DISCUSSION

Question. Mr. Bugbee, can you see any effect of auxiliaries on the fire department of the future with regard to reduction of personnel and equipment? Will the population feel that they can get along without the fire department by the use of these auxiliary organizations?

Mr. Bugbee. I think it is a matter of primary organization at the start. It should be made plain to the auxiliaries

that they are being called purely for the emergency, that they are volunteers subject to the local fire departments and administrators.

Question. You spoke about 6,000 inspectors making investigations and suggestions for improvements. Do you know of any time where they notified the fire departments of the suggestions which they have made for improvements?

Mr. Bugbee. Those 6,000 inspectors are pooled through the Bureau for Industrial Protection, and whatever they recommend goes through the F. B. I. Whether the F. B. I. makes any of their recommendations available to the fire departments I don't know.

Question. You were perhaps a little modest when you talked about the codes in cities throughout the country. You didn't mention Massachusetts. Don't you think the Department of Public Safety code there is pretty good?

Mr. Bugbee. Yes; I do.

Question. Mr. Bugbee, it is a well-known fact that in the last 10 years fire officials have been united in saying that the insurance companies are rather lax in enforcing recommendations made by their inspectors insofar as correcting conditions are concerned. What do you have to say about that?

Mr. Bugbee. That is a little out of my field, because I am not an insurance man. Some insurance inspectors are better than others, some more conscientious than others. In competition for business some insurance men may stiffen up their requirements, with the thought that they will get lower rates to offer and thereby sell more insurance; or they may be lax thinking that if they don't ask too much, they may get by.

I do think that the average insurance inspector, as I know him, has been somewhat maligned. I think he is competent and well-trained.

Question. Don't you believe that it would be good policy if insurance inspectors would cooperate more fully with the fire department—not only during the emergency necessarily, but at all times?

Mr. Bugbee. Yes. It is a little difficult to work out. The inspector may be told to make a confidential report to his company. He can't talk because he may get in trouble with the insured; he may disclose a secret process. Many times the insurance inspector is told when he comes into the plant that he can't give out any information to anyone.

Question. Mr. Bugbee, I believe that 90 percent of the fire departments in the country are undermanned. The same is true with apparatus. Now, what I can't understand is this: In my city, we have had recommendations from the board of underwriters, and we carried those recommendations out thoroughly. We built several engine houses and bought new trucks, and are buying them still. Yet the insurance rate jumps up. When I go before the finance board, what do I have to say about it? That's not fair. The underwriters don't work with the fire department officials at all, so far as I can see.

Mr. Bugbee. I am really not competent to attack or defend the insurance business because I don't know enough about it. You must remember, though, that a city rating includes many factors besides just the fire department.

Question. I come from a manufacturing town, and the firms all have their own departments. I have tried to get them to standardize their couplings and nozzles. The insurance company says no. When they want to shut down,

they have to go half a mile to shut their pump before they can shut their line down. I can't understand it.

Mr. Bugbee. I can't, either.

Question. Can you tell us about that new fire code being distributed by the National Board of Fire Underwriters?

Mr. Bugbee. Yes; it is a new edition of a code that they have been publishing for several years; the first I think was 12 years ago. Then they published a second one in 1938, and this one has just been completed.

As far as I know, it is a good guide. They picked out what they thought were the most important things to be included in the fire-prevention code, and it represents their idea. Your idea might be different, mine might be different. I think their proposed code is all right. It will help a whole lot toward standardizing.

Question. In regard to that inspection card you have mentioned, the city of Everett, Massachusetts, has two splendid specimens. On one side of the card are 39 items, and on the other side is the first floor and basement plan. If any of you men are interested, you can write to the Chief of the Fire Department in Everett and get the card.

Mr. Bugbee. If you are interested in record forms of all kinds, you might like to know that there is a "Model Record and Reporting System for Fire Departments" that has been published. It is very complete. It includes all sorts of fire department records. It was based on a study of the record systems used by a hundred fire departments in this country. It is published by Public Administration Service, 1313 East 60th Street, Chicago. I think it sells for $2. It is quite a comprehensive book.

IIB

FIRE APPARATUS AND EQUIPMENT AND EMERGENCY WATER SUPPLIES

By

James W. Just

Maryland State Fire Coordinator

It is not the purpose at this time to discuss the construction, operation, or maintenance of your present equipment, but to give you a brief analysis of some of the problems you may be called upon to face.

Practically every fire department in the United States is either underequipped or in the position of depending upon obsolete apparatus. If apparatus were ordered now, it would be many months before delivery could be made, if at all. As a matter of fact, there are many makes of pumps which are unobtainable even now.

Face the Facts Immediately.

The emergency confronting us is not one which is going to await "future orders." Our job is to face the facts immediately, plan a defense program accordingly, and act decisively.

Just *what* are we going to do for pump capacity if an air attack should hit us next month?

One partial solution which has been offered is in utilizing to the limit the small front end mounted pump of 300 to 500 gallons capacity. Fortunately, we understand, this type pump is still available in quantity. This pump can be mounted on almost any type of vehicle, with a booster tank

of from 250 to 1,000 gallons, and will prove a very serviceable piece of emergency equipment.

This arrangement, however, does not entirely solve the problem the trailer pump solves; that is, in getting through debris-littered streets handily. However, when mounted on a light truck, you will be able to take it to places where it would be impossible to reach in an 8- or 10-ton standard engine.

The possibility of mounting such a pump on all city-owned vehicles should be considered. Industrial plants might also be convinced of the advisability of so equipping some of their trucks. In such cases, the booster tank installation could be eliminated and in an emergency drums of water carried on the truck.

Emergency ladder pipe hook-ups may be prepared by installing brackets on the side of city service trucks, street trucks, sand and gravel trucks, where, in an emergency, ordinary straight beam ladders can be bracketed in a vertical position for an elevated nozzle operation. This plan has been used successfully for years in the Cedar Rapids, Iowa, Fire Department.

Equipping Rescue Trucks.

Any type of truck can be equipped as a combination rescue and salvage truck, and equipped as well with foam and other special extinguishing agents. Rescue trucks should be *properly* equipped. Many so-called rescue companies are very short on actual rescue equipment.

In short, the chief should not only study but put into action definite plans for the conversion of various types of vehicles for fire service.

Protection Against Sabotage.

Another matter that should have the careful consideration of the fire department is the protection of apparatus and equipment against both sabotage and bombing.

The saboteur, in order to insure a reasonable chance of success in any act of sabotage against a war industry, would consider it of utmost importance to cripple the fire department. There are many ways in which the fire fighting service could be crippled, all of which must be guarded against. Particularly vulnerable items are the alarm system, the pumping units, other motorized equipment, and the hydrant.

Constant vigilance is necessary to guard against damage to the equipment, both from within and from without the department. Loafers and strangers should not be allowed around a fire hall or the apparatus, nor about the pumping station. The personnel of the fire department should be carefully scrutinized as the enemy is likely to endeavor to place his agents in positions where they have the best opportunity to commit acts of sabotage. The fire department is one of the best possible places from the enemy's point of view in which to cause the greatest dislocation of effort in an emergency resulting from fire and explosions.

Alarm System.

The fire alarm constitutes the nerve system of the fire department and upon it depends the initiation and coordination of the department's efforts to deal with an emergency. It plays a very important part in the case of a large fire or a large number of simultaneous fires and a break-down of the lines of communication could lead to

utter confusion and disastrous delays. In view of its vital importance, the fire-alarm system should receive careful and constant supervision so that any tampering with it will be detected as soon as possible.

Telephone communication to fire-department headquarters and with substations should receive the same careful supervision. Some of the most disastrous results of bombing during the present war have been from the disruption of the communication lines, a break-down in which is second in consequences only to an interruption in the water supply. To meet any extreme circumstances, a system of runners (with bicycles or cars) should be organized in such a way that it could be put into operation with a minimum of delay.

Apparatus.

There are many ways in which the various pieces of apparatus can be put out of commission without the trouble being detected until steps are taken to put the equipment to use. Foreign materials in the lubricants for the engines and pumps might put them out of commission after a very short time on duty. Foreign materials in the fuel tank might cause a piece of apparatus to stall before reaching the fire at all. Similar results can be attained by tampering with the fuel line or the ignition system on trucks, by draining out the lubricant, or by placing small metallic objects where they will become engaged in the gears and damage them.

In order to avoid any of these possibilities, the various pieces of apparatus should be protected from tampering by unauthorized persons and should be checked and tested

frequently to be sure that they are in working condition. The servicing of the various motor vehicles should be allotted to certain individuals who would be held responsible. Strict enforcement of such a rule would go a long way toward eliminating the likelihood of any trouble of this nature.

Hydrants and Mains.

Hydrants are particularly subject to damage and attack. They should be checked, particularly in important areas, to see that they are in proper working order. There is not only the question of deliberate interference with the hydrants, but also the possibility of freezing or other accidental damage. The problem of what steps to take for an alternative water supply, if the mains themselves are damaged, should also be considered.

Personnel.

Someone should be in attendance at all times at the fire hall to guard against interference with the equipment and against trespassers. A complete history should be obtained of every member of the department. It should include information with respect to his inclinations and attitude toward our war effort, any subversive activities in the past, and his associations with any organizations of an undesirable character. Anyone under suspicion should be carefully watched, but it cannot be too strongly emphasized that he should not be allowed to realize that he is under suspicion or is being watched.

Protection Against Air Attack.

In the event of an air attack, either with explosives or incendiaries, fire stations are just as likely to be damaged as any other buildings. In view of their vital importance under such circumstances, it is urgent that they be provided with all the protection from damage that is practicable. Measures taken to afford protection should take into consideration the following:

(*a*) The vulnerability of the switchboard and fire-alarm room.
(*b*) Safe accommodation for officers and men.
(*c*) Accommodation for mustering purposes in contingencies and emergencies.
(*d*) The ability of the building construction to withstand concussion blasts and splinters.
(*e*) Concrete or metal shelters as accommodation by day or night (if subsequent developments make them necessary).
(*f*) The storage of flammable liquids underground and sufficiently removed from the fire department premises.
(*g*) Provision for emergency lighting.
(*h*) The advance location of places where equipment may be moved. This is important where there is more than one piece of apparatus in one station. Such equipment should be decentralized during raids to prevent total destruction by any one bomb.

Reinforcement and Protection of Building.

In providing against bombing from the air, measures should be considered with regard to the strengthening of

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the floors so that they will withstand the weight of the debris from the collapse of the roof and walls above. Precautions must also be taken against incendiary bombs and they should apply to the entire roof and the upper story or attic as well as to alternative means of exit. Following are specific measures to be considered:

(*a*) The strengthening of floors can most readily be accomplished by timber or steel strutting.

(*b*) If the existing walls are not sufficiently strong to resist penetration by splinters or collapse from concussion, the "protected" accommodation for personnel, fire-alarm equipment, etc., can be further protected by means of sandbags.

(*c*) Windows are vulnerable points, but substantial protection can be given by providing them with heavy shutters which can be closed when an emergency arises. Alternatively, they can be protected with a wall of sandbags 2 feet or more in thickness resting on the window sill and on a projecting ledge, extending so as to overlap the window opening by at least 12 inches on all sides.

(*d*) Roofs of sufficient strength can be partially protected by a layer of sand bags. As incendiary bombs usually pierce the roof and become lodged in the attic or on the top floor, some protection against fire should be provided in these areas. A considerable degree of protection can be given by covering the floor with a 2-inch layer of sand and treating the upper woodwork with a flame-resisting paint or plaster. With this protection and a water spray, an incendiary bomb can be prevented from doing any serious damage.

The same principles should be applied in the protection of a fire hall as in the protection of any other building,

but their application should be even more intensified than with the ordinary building because of the dependence of other properties upon the personnel and equipment in the fire halls for protection. This is true not only under threat of air raids but under all circumstances, since the fire department is likely to be called upon to deal with the emergencies at any time.

Coordination With Neighboring Departments.

The chief of department should secure through the State fire coordination a list of all available apparatus and equipment within a 20- or 25-mile radius of the city. Then, in cooperation with the coordinator and the various neighboring departments, set up a definite call system for outside help to the municipality. This, of course, should be so arranged that no neighboring community will be left unprotected.

Water Supply.

No chief will argue as to the advisability of an adequate water supply for fire fiighting. Yet a great many of us have not yet fully realized that in most of our cities, one well placed HE bomb would raise havoc with the water supply. In fact, in many cities the supply could be entirely cut off. In others, entire large sections of the city could be left without water for fire protection.

One of the most important duties of the fire department today is to make an immediate survey to ascertain exactly what the possibilities are. We have seen cases where a town had two well-separated sources of supply, yet due to a lack of sufficient sectional control valves the crippling of

either source of supply would leave the greater part of the city without water.

While in many cases the water department has exclusive control over the water system, the fire department should survey the situation from its own angle and fight for such changes or improvements as will safeguard the water supply for emergencies.

The occurrence of a large number of fires simultaneously is not necessarily dependent upon air raids with incendiary bombs. A carefully executed plan by a designing and ruthless enemy could accomplish the same results by simpler methods, and there is no right to assume that he will not resort to such tactic, particularly as the situation becomes more desperate for him.

Try the Emergency Sources.

A careful survey should be made and all additional sources of water supply should be mapped. These include rivers, creeks, swimming pools, cisterns, wells, industrial water tanks, railroad water tanks, industrial vats. *It is not sufficient to merely list these emergency supplies.* The fire department should try using them—to make sure they are approachable, unobstructed, reliable. Companies should practice relaying water from such sources, possibly from one such supply to another. Incidentally, this should also be tried in a black-out.

The department should urge the establishment of cisterns in strategic locations where failure of water would be calamitous. It should urge business interests and house owners to keep any possible sources of supply filled.

Methods should be practised of building dams and lash-

ing up hard suctions, in order to offset possibility of off-threads or damaged threads.

(Illustrate HS hook-up on board.)

It is also recommended that departments investigate the possibilities of the English "Gulley Dam" (illustrate) for utilizing excess water on the fire ground.

Inventory the Portable Tanks.

Inventory should be taken of wholesale hardware and implement houses, as well as of retail establishments to learn where—and in what numbers—portable tanks such as farm horse troughs and metal vats of various kinds may be found. Strategic locations for the location of these emergency tanks should be planned in advance. Advance arrangements should be made for collecting, placing, and filling such containers, possibly with some local cartage company.

The department should have a list of all privately owned fire pumps in business or industrial plants, as well as the amount and size of available hose at such locations, and information as to source of water supply for such pumps.

Householders in possible raid areas should be required to keep all available tubs, buckets, etc., filled for emergency use.

Proper arrangements should be made with the water company and an educational program conducted to teach the public to conserve the available water supply.

Practice Water Relay.

Departments should be prepared, through study and practice, to relay water from hydrant to hydrant in by-

passing ruptured sections of mains, and water companies should have well-manned and equipped emergency repair crews constantly available.

All sources of water supply should be learned and possibly marked so they may be located and used in a blackout. This means that all company members should not only be familiar with the location but with surrounding conditions as well.

Fire hydrants should be stamped showing the size of main and pressure, as an assistance not only to the local department but to any outside companies reporting in an emergency.

Many of you have undoubtedly made intensive study of these subjects, and have probably done something about it. We would like to hear your suggestions.

ROLE OF FIRE SERVICE IN NATIONAL DEFENSE

By

Fred Shepperd

Major Brayton. Fred Shepperd has been connected with fire service since way back in 1910. I think you are all acquainted with him in his function as manager of the International Association of Fire Chief Organizations and as editor of Fire Engineer. I expect most of you in your libraries have several text books which he has written.

I don't know what Mr. Shepperd's slant on the situation is. I am just asking him to tell it to you. But I want you fellows to feel that we have got an organization here which is capable of giving a lot of information to the fire departments over the United States and Canada, and that we appreciate that sort of cooperation.

Mr. Fred Shepperd. It has been a number of years since I have had the pleasure of talking before such a class. I was rather surprised to come here this morning and find such qualified fire instructors as Major Brayton. He has been engaged in this work for years, and set the pace in fire-department training in Texas. We have observed many of the innovations he has inaugurated. It is most encouraging to find you have such a fine instructor. I am glad to be here with him.

The topic assigned to me is The Role of Fire Service in National Defense.

In order to discuss the subject intelligently, we must go further than just outlining the role. We must point out some of the things a fire department will be faced with, and also include such information as will be of use in fulfilling the role.

In a report entitled "Civilian Defense," prepared by the Advisory Committee on Fire Defense and issued by the Division of State and Local Cooperation of the Office for Emergency Management, the following statement appears:

"In these days of total defense, a nation's secondary lines of defense, including the organization of fire services and the provision of police protection, are almost as important as the military or first line of defense. In some cases, these secondary lines of defense may be of equal importance to the nation."

The experience of the British fire service would seem to indicate that civil defense *is* fire defense. It need only be pointed out that the London fire department alone has averaged 700 fires a day, with a top of 2,000 fires in one night, to appreciate the tremendous task with which they are faced. These figures do not include incipient fires that were extinguished by fire wardens, police, or the public, without the aid of the fire department. The multiplicity of fires was not all that taxed the fire department. In addition to the fires, water mains were crippled by high explosive bombs, streets were littered and in some cases impassable due to debris. Roadways were blocked by bomb pits, gas mains were ruptured and gas ignited, and communication systems were seriously damaged.

In discussing the role of our fire service in national defense, it will be helpful to review briefly the experiences of our brother firefighters abroad, particularly with regard

to what they have had to face during aerial attack, because that will possibly represent the major problem to be faced here.

Recent "blitz" bombings in England show a definite pattern or plan, though this plan may be varied from time to time. First to arrive are the planes which drop flares. These flares light up the area to be bombed. Then come the planes carrying incendiary bombs, which are strewn over the area. Following the incendiaries, high-explosive bombs are dropped. These latter bombs drive to cover those who may be trying to extinguish fires started by the incendiary bombs and also serve to wreck buildings and thereby make them easier prey to fire. And then in some instances oil bombs are subsequently dropped to spread fires over wrecked areas. Where fires have gained headway, enemy planes frequently machine-gun the firemen to hinder their operations and thus aid the spreading of fires.

That America will ever be subjected to the same intensified air attacks that England has experienced seems, to the layman, to be most unlikely. Surely the general use of high-explosive bombs, on a large scale, on other than military objectives would not be in order, because of the cost of these bombs, the cost of transporting them, and their limited effectiveness. But the use of incendiary bombs, where a $10 bomb might start a $10,000,000 fire, would prove attractive to any enemy. The extensive use of incendiary bombs is therefore indicated if we become actively engaged in the war and if any bombing is done.

Set Fires.

In considering incendiary fires, we must not overlook the saboteur. Sabotage by fire is effective, and evidence of

the crime is frequently destroyed in the fire. But sabotage can be controlled largely by vigilance, and a multiplicity of fires at one time within a city from this cause is improbable. On the other hand, air attack can neither be checked by vigilance, nor can the number of fires caused be reduced by the same means. The fire department, with its auxiliaries, must be prepared to extinguish them. If it fails in this, conflagration may result. A 4½ square-mile area in one British city was leveled by fire during a single air attack.

Even though the enemy planes which bombed London had but a short distance to travel from their base in France just across the English Channel, and thus could carry on a sustained bombardment with high explosive bombs, it is interesting to learn that the damage done by incendiary bombs in London was far greater than that done by the high explosive type.

APPARATUS

To fill its role, and fill it with full effectiveness, the fire service must first look to its apparatus. Specialized fires require specialized apparatus, a multiplicity of fires requires widely distributed apparatus, and large fires require apparatus of large capacity.

The first step in preparedness is to bring the department up to its full strength by replacing obsolete machines with new, and by restoring the full personnel to fire companies. After this has been accomplished, then special auxiliary apparatus may be provided.

Experience in England has shown that the small trailer pump is effective and economical for wartime service. Because of its small size, it can be stored at convenient points

within buildings and thus will be near at hand when needed. Its capacity is such that it can handle any small fire; or it can serve, when used in numbers, with good effect at larger blazes.

The number of trailer pumps employed in London is on a basis of 25 to 30 for each regular fire company. In American cities where there are relatively more companies in proportion to population than in London, the ratio would be smaller. Furthermore, with less intensified bombing as expected here, the number of trailer pumps needed would be even less. Possibly 10 to 15 trailers per regular company would be sufficient for American cities.

HIGH BUILDING PROTECTION

When a high-explosive bomb strikes the top of a building the water tank thereon supplying the sprinkler and standpipe systems of the building is put out of commission, along with both systems. For that reason, fire fighting operations in these taller structures are difficult.

To speed up operations and to enable the fire department to get streams quickly in operation on the fire, the use of aerial ladders—preferably of the metal, power-operated type—is essential. So effective have these aerial ladders proven in British cities that one aerial ladder is being provided for each pumper in the service. It is recommended that the ratio of aerial ladders to pumpers be also increased in fire departments of cities along the Atlantic and Pacific seaboards.

Fire hose, the medium through which water is carried from its source to the fire, is the most important tool of modern fire departments. Without hose, the most powerful fire engines are worthless as fire-extinguishing machines.

Where a large number of fires are burning at the same time, a single fire company may have to stretch three or four lines. Unless there is a reserve supply of hose, this cannot be done because each fire engine carries only from 1,000 to 2,000 feet of hose.

Present hose supply of fire departments within the probable zone of attack should be doubled. And because long stretches will be common, and high pressure at engines will be required to produce satisfactory pressures at nozzles, only high-grade hose should be considered. During a multiplicity of fires when each engine and each line must perform, the failure of a single line of hose may prove disastrous.

In connection with the use of fire streams during air attack, certain devices have proven especially valuable. The deck gun, mounted on a fire engine or other piece of apparatus, delivers a large stream of high pressure and holds its direction without outside aid. It can be aimed to deliver a stream at any point desired, and, when left by itself, it does not change this direction. This characteristic is particularly valuable when firemen operating on a fire are driven to cover by enemy planes. The stream will continue to do its work while the firemen take shelter. Pipe holders, placed on the ground, have proven equally valuable.

Extinguishers.

The correct use of the proper types of extinguishing agents plays a very important part in the role of the fire service in national defense. A brief review of these agents, with a word about their limitations, may be of interest.

Probably the most novel extinguishing agent today is water fog. This fog is produced by the discharge of water, usually under fairly high pressure, through a special atomizing nozzle. In some cases the extinguishing effect is produced by quenching—that is, the cooling of the combustible material to a point below its reignition point; in other cases, particularly in confined fires, the result is brought about by smothering the fire, the fog being vaporized by the heat of the fire and the steam so produced smothering the fire. In heavy oil fires, the fog produces an emulsion on the surface of the burning oil and this emulsion aids in the extinguishment of the fire.

Of particular interest to us today is the effectiveness of the fog nozzle in combating fires involving the magnesium (or electron metal) incendiary bomb. While the fog tends to increase the intensity of combustion of the bomb, it does not cause the violent reaction (sputtering) produced by a solid water stream striking the burning bomb. And at the same time the fog extinguishes the fire in any combustible material which may be in contact with the bomb.

The stirrup pump is used very widely abroad for handling incipient fires caused by the 1-kilogram bomb. The proper use of this pump, which employs water, requires three persons—one operates the pump, one handles the nozzle, and the third carries water for the container in which the suction of the pump rests. Properly used, it is safe and effective for small magnesium bomb fires.

The knapsack type extinguisher, which is a 5-gallon tank curved to fit the back and carried by straps, is fitted with a hand-operated piston pump, by which the operator can deliver a stream a distance of 30 feet or more. This is a

one-man extinguisher and has proven very effective on the incipient fire.

The soda and acid extinguisher is a cylindrical tank of 2½- to 3-gallons capacity, fitted with hose and nozzle. Mixing together within the extinguisher a sodium bicarbonate solution and sulphuric acid creates carbon dioxide gas, which provides the expelling force for the soda solution. This extinguisher is about as effective in extinguishing fires as plain water in an amount equivalent to the fluid contents of the extinguisher. It is safe for use on all fires on which plain water might be used.

The carbon tetrachloride extinguisher is not safe for use on incendiary bombs.

Carbon dioxide gas fire extinguishers are not effective on magnesium bomb fires because they increase, rather than decrease, the intensity of combustion.

Dry sand and powdered talc are useful in controlling the burning magnesium bomb, although they do not always stop the burning. Quite recently a powder has been developed by a magnesium manufacturer and an extinguisher maker which is said to extinguish the fire involving an electron metal bomb.

Water Supply.

Despite the many extinguishers and extinguishing methods developed, water still remains the first line of fire defense. In fact, it is the only agent that can be used today in the control of conflagrations. Hence its great importance in civil defense. There is not a city in the United States that has not a water supply capable of meeting all peacetime fire-fighting needs. But unfor-

tunately, every water supply system is highly vulnerable to aerial attack. It is not the reservoirs that suffer. It is the underground mains carrying the supply throughout the city. During a heavy aerial attack in London, the breaks in water mains may exceed one hundred.

As water mains in this country are buried at depths of only 2 to 6 feet, it does not take a large bomb to penetrate the pavement and earth beneath it and rupture a main. And unless the water main system is cross-connected and valved, so that any broken section may be segregated, serious bleeding of the water system may result from pipe rupture caused by bombs. In one British city, nearly 60 percent of the water system was put out of commission during a "blitz" attack. It was 4 days before service was entirely restored.

Provision of water supply looms as a vital problem in civil defense.

In the event of serious damage to the water system, reliance must be placed on other sources of water. Hence a thorough study should be made of the various sources of auxiliary supply that might be used. These sources should be tested in actual practice to assure the familiarity necessary for most effective use. Auxiliary sources which should be investigated and catalogued might include rivers, ponds, lakes, pools, cisterns, wells, roof tanks, private storage tanks, industrial water plants, swimming pools, and other available sources.

In connection with the use of auxiliary sources at a distance, men must be fully instructed in the use of *relay lines.* The only limitation as to the distance water can be delivered through fire hose is the number of pumping

engines available, and the supply of hose on hand. At the big London fire, water was taken from the Thames River and sent through hose lines miles in length.

The men should be fully informed, too, in the bridging of broken sections of water mains by use of hose lines. If upon isolating a break in a main by closing valves, the main on the far side is deprived of water, it is necessary to supply this main by use of hose—preferably of large diameter—stretched across the break from hydrant to hydrant.

Periodical inspection of hydrants should be made by members of the fire department to make sure that they are in good condition and ready for operation. It is desirable to have hydrants painted white, so that they can be readily located during a black-out. Either the size of main to which the hydrant is attached, or some other symbol indicating the probable flow from hydrant, should be painted on the hydrant barrel or hood. It is also desirable to paint a white line across the street at hydrant location to facilitate the location of hydrant during black-out.

Reuse of Water.

To conserve water supply, when many fires are burning, water should be reused. That is, water flowing from a building, industrial plant, or other structure should be reused for fire-fighting operations. It is not recommended, however, that this practice be followed at oil plants. At a London fire the officer in command was amazed to note the fierceness with which a fire burned when a stream was directed on it, only to find that the pumper was picking up oil with the water from a sluice. The oil found its way into a ditch from a bombed oil storage tank.

The work of the fire department in water conservation does not end with its own efforts. It should, by all available means, urge the public to keep water stored in tubs, bathtubs, and other containers for use in the event of attack by incendiary bombs.

Training Private Brigades.

In its role of national defense, the fire service must reach beyond its own confines. The organization and training of private brigades in industrial plants must be undertaken and carried to completion, for in the event of numerous fires being created by incendiary attack, the municipal fire department will have its hands full in combating fires in commercial and business buildings and dwellings. The industrial plant may have to take care of its own fires.

Furthermore, industrial plant brigades can be of material assistance to the municipal department if they are well drilled.

Mutual Aid.

In this day of high-speed motor vehicles and good roads, mutual aid between neighboring municipalities, in the event of disasters of major proportions, is not only possible, but is practical and highly effective. County emergency plans of cooperation have been in operation for several years, with outstanding success.

In a plan for mutual aid, an inventory of available equipment is the first essential. Then a code of signals must be formulated to secure efficient operation. With such a sys-

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tem properly developed, it is possible to call just such equipment and personnel as is needed.

A well-ordered mutual-aid plan includes not only fire apparatus, demolition equipment, rescue apparatus, ambulances, first-aid cars, and other special duty equipment, but also a roster of skilled artisans, such as mechanics, welders, electricians, and utility employees.

From the standpoint of fire fighting, it is imperative that hose adapters be provided so that each fire department can use the hose and hydrants of all other departments in the group.

It is highly beneficial for an emergency plan, or mutual-aid organization, to carry out mock musters, so that in the event of an emergency confusion will be avoided.

Auxiliaries.

No peacetime fire department has the manpower to handle situations brought about by air attacks. In London it was necessary to develop an auxiliary force of fire fighters which outnumbers the regular department by 20 to 1. An auxiliary force must likewise be established in American cities, and trained by the regular fire fighters.

Members for such an auxiliary force may be secured from among pensioned firemen, civil-service eligibles for the fire department, members of veterans, civic, fraternal, and similar societies; members of trade-unions and others employed in certain industries; tradesmen and others whose work does not take them from the district.

As noted previously, these auxiliaries must be trained by the regular department. Instruction courses should include the following: Fire prevention, fire fighting, fire-

alarm operation, characteristics and functioning of incendiary, high explosive, and other types of bombs; detection and prevention of sabotage and arson; use of fire apparatus and various types of fire-fighting tools; first aid and rescue work. The same training that is given regular firemen should be followed as closely as possible in these training courses—that is, the course should cover use of standard and mobile equipment as noted previously; use of hose and ladders; types of extinguishers, gas masks, and other equipment.

Auxiliaries, properly trained, have proven themselves very capable fire fighters abroad. The experience here should be similar.

The auxiliary force should include lookout men, or spotters, who are capable of handling incipient fires.

Normally, the first duty of the fire department is to save life, and to accomplish this effectively in the event of air raid requires both equipment and training. Each incident is a problem in itself and no general instructions might be given which could be applied to every case. But life saving does not include only the rescue of persons in difficulty. It includes preventive measures as well. In this category fall evacuation drills. Such drills should be conducted in schools, office buildings, and other places where large numbers of persons congregate or are housed. Evacuation drills should be conducted under the direct supervision of firemen of the regular force, if possible.

Of utmost importance to the safety and health of a community is the maintenance of its utility service. Electric power, gas, water, and transportation facilities, as well as oil supply, are vital to the operation of a municipal corporation. The protection of these utilities is one of the most

important tasks of the fire service. Insistence upon good housekeeping—that is, the removal of waste and rubbish—and keeping of extinguishing equipment in good condition are essential requirements, in the protection of these utilities. Oil plants, because of their extremely hazardous nature, will probably be equipped with dikes and other safety features. Condition of such dikes and other emergency equipment should be checked.

Inspection Work.

Periodical inspection of industrial plants, commercial buildings, places of public assembly, and places of human habitation is a most essential part of civil defense. If premises are kept clean, the danger of fire spreading is reduced materially. Frequently, due to rush of work, combustible stocks are permitted to accumulate in factories, or waste materials may collect, and then in the event of fire starting, damage may be extensive. Inspection work should include the checking not only of common hazards but of the uncommon as well. Thoroughness of inspection by firemen is reflected directly by decrease in fires and fire losses.

Educating the Public.

It will be the duty of the fire service to inform the public in methods of cooperating with the fire departments so that fire losses may be kept to a minimum. Many agencies for such public education are available and can be used with effectiveness. The use of newspapers, radio, and speakers from the fire department are all in order. Informing the public on what to do to minimize fire hazards, what precautionary steps they should take to guard against

fires from incendiary bombs, and what to do in the event of a serious fire situation should all be part of the program. Fire-department members may address clubs, schools, business meetings, and fraternal society gatherings to spread the doctrine of fire safety. Radio addresses are particularly effective in accomplishing this end.

In the larger departments, a speakers' bureau may be formed. Men of ability as speakers should be selected as members of the bureau. Not only can they instruct the public in fire defense, but they can develop cooperation on the part of the public and industry, and commercial, mercantile, and other groups in reducing fires.

Sabotage and Arson.

Even though the danger of immediate bombing may not be great the danger of property destruction by arson and sabotage is very real. Many of the fires of unknown origin which have occurred recently may well be classed as due to sabotage.

Sabotage by fire usually includes interfering with the fire protection of the property to be attacked, and then starting a fire. Interfering with the fire protection of the property may consist of tampering with fire-fighting equipment by plugging the nozzles of soda and acid extinguishers, emptying the acid, or soda and water mixture, from the extinguishers, or both; cutting the discharge hose of the soda and acid extinguishers; replacing fluid in the carbon-tetrachloride extinguisher with an inflammable liquid; emptying the contents of the carbon-tetrachloride extinguisher; or releasing the gas from the carbon-dioxide type of extinguisher.

Standpipe systems in buildings may be made inoperative by closing valves, removing valve wheels, and damaging hose and hose connections on standpipes. Burring the threads on the standpipe hose outlets will make use of these outlets impossible unless suitable adapters or universal couplings are carried by the fire department. Damaging the private hose in a plant is designed chiefly to delay the extinguishing operations in order to give the fire opportunity to spread. Sprinkler systems are also made inoperative by closing the valves and removing valve wheels.

Fire-alarm signalling systems may be put out of commission, fire hydrants, damaged, telephone lines interrupted, and watchmen's signalling systems put out of service. Such damage is done so as to interfere with the prompt detection, prompt reporting, and effective fire-fighting operations.

Where the municipal fire department is cooperating properly with the industries likely to be attacked by saboteurs, the following recommendations should be made by the fire department to plant officials: Periodical inspection of all fire-fighting equipment; extinguishers should be so sealed that their removal or tampering with would be quickly detected; instructions of workmen, or fire-brigade members if there is a brigade in the plant, in precautions to take before using extinguishers.

To prevent sprinkler systems or standpipe systems from being put out of commission, daily inspections should be made, and vigilance should be maintained to prevent tampering with equipment.

The chemicals employed by the incendiary are chiefly designed to start fire rather than to speed it up. Of the

chemicals used for this purpose, sodium, potassium, phosphorus, and permanganate of potash (potassium permanganate) are the most commonly used.

Sodium is a metal of silver-like appearance and melts at 208° F. It decomposes water, upon contact with it, and frees hydrogen. The high temperature created by the reaction ignites the hydrogen. Thus sodium is ignited when brought into contact with water. It is usually kept submerged in kerosene.

Potassium in appearance and in action is very much the same as sodium. It is a soft, waxlike, silvery metal, which ignites when brought in contact with water. It is normally kept submerged in kerosene.

Phosphorus is a light yellow, waxlike, semitransparent substance. It is luminous and phosphorescent in the dark. It is very poisonous, and takes fire on contact with air. It is usually shipped and kept in containers filled with water.

Permanganate of potash (potassium permanganate) is usually found in the form of dark purple crystals. When treated with sulphuric acid, in the presence of combustible materials or inflammable gases, fire may result.

Other materials used for sabotage by fire include: guncotton, which in its true form looks very much like ordinary cotton. It ignites readily and is extremely inflammable.

Matches, used in connection with cigarettes or in connection with incendiary "plants."

Gases, including acetylene gas generated by calcium carbide in contact with water.

Celluloid scrap.

Electrical heating devices.

Clocks with fire-starting devices and inflammable materials.

Incendiary "pencils" of different forms.

Methods of Sabotage by Arson.

The methods of starting fires, as employed by saboteurs, vary widely. However, in practically all cases fires are set in readily combustible materials. Ignition may be brought about by direct application of fire or by the use of incendiary devices or chemicals subject to spontaneous ignition.

For example, sodium may be placed where water may reach it, such as under openings in the roof, or at the bottom of the water spout. Rain reaching it would result in ignition of the sodium and materials adjacent to it.

One novel plan used by saboteurs is to wrap sodium in a heavy paper covering and toss it into the water around piers or wharves. Sodium, being lighter than water, will float and eventually the water will work through the paper covering and reach the sodium, whereupon ignition takes place. If the sodium at the time of ignition is in contact with oil-coated piles under a pier, ignition of the pier may result.

Phosphorus lends itself even better than sodium to the starting of fires. As long as it is covered by water, or wrapped in water-soaked coverings, no fire can start. But upon the drying out of cover, or removal of the water, the phosphorus will take fire upon exposure to the air.

One method of starting fires by phosphorus, utilizing this characteristic, is to place phosphorus in a shallow container of water, and put a small hole in the bottom of the container so that the water will slowly drip out. When

the water has drained out, and the phosphorus left exposed to the air, fire will start. If combustible material such as oil-soaked waste is in contact with the phosphorus at this time, then fire will result.

A quicker fire is produced, using phosphorus, by wrapping a moist cover around the phosphorus. When the covering material dries out fire starts.

Potassium acts in very much the same manner as sodium and may be used in lieu of sodium by saboteurs.

One of the most ingenious devices for starting fire, employing chemical action, first made its appearance during the last World War. At that time it consisted of a short piece of lead tubing in the center of which was placed a thin copper disk, soldered to the tubing around its periphery. In one end of the tubing was placed picric acid and at the other end, sulphuric acid. Then both ends of the tube were plugged with wax and capped with lead caps.

The sulphuric acid would eat through one copper disk and upon reaching the picric acid, intense fire would occur. Other types of chemicals, which reacted upon each other so as to create fire, were also employed in these devices.

The more recent adaptation of this device is in the "incendiary pencil." This has the appearance of an ordinary pencil and is fitted with lead and eraser. However, the inside of the pencil follows very much the same design as the tube described above.

The time taken for the sulphuric acid to eat through the separating disk, or copper partition within the pencil, depends upon the thickness of the disk.

These pencils may be deposited in combustible materials being shipped in trains, ships, trucks or stored in plants. When the two chemicals ultimately mix, fire occurs.

Cigarettes are used usually in connection with matches for starting fires.

The cigarette is wrapped in the center of a bundle of matches, with their heads turned toward the lit end of the cigarette. When the burning end of the cigarette reaches the matches, the matches are ignited and combustible material in contact with the matches is set afire.

Gases are sometimes utilized for starting fires, although there is great danger of explosion where gas is free in the atmosphere. The usual plan is to leave an open flame in the room where gas is permitted to escape, and when such time arrives as the gas reaches the fire, there is a flash back to the source, whereupon fire in combustible materials at that point is started. However, occasionally the gas reaches an explosive mixture in the room before the open flame is encountered, with the result that explosion occurs, and usually without subsequent fire.

Celluloid scrap is employed chiefly to speed up the start of a fire. Some form of ignition is used, such as cigarettes and matches, and the celluloid intensifies the fire when the matches are ignited.

Ordinary tallow candles are probably the most commonly used devices for starting delayed action fires. As such candles burn at the rate of approximately 1⅓ inches per hour, the arsonist can, by using a long candle, give himself plenty of time to get away and to establish an alibi.

Where candles are used, streamers are also commonly employed. The candle starts the fire at the source and fire travels along the streamers to different points of the building or plant.

Clockworks or clocks have been used in the past for starting fires, but due to the fact that the evidence still remains

after the fire, this type of "plant" is waning in popularity. Mechanisms may be used to release inflammable liquids on a candle or to strike a flame by scratching or rubbing a match.

One novel device found by investigators after a suspected fire consisted of a board arranged as a seesaw. On one end of the seesaw was a weight and on the other end a container with a small hole in the bottom. The container was filled with water and, upon the water draining out, the weight on the other end of the seesaw caused that end to drop, scratching a match on a piece of emery cloth. Excelsior in the neighborhood of the match carried the fire from the device to combustible materials in the neighborhood.

The use of volatile inflammable liquids has become more common by the incendiary. The volatile liquid may be placed in open containers near a source of ignition. When an explosive mixture of the liquid vapor and air is reached, there is a flash-back and the liquid ignites. Highly inflammable liquids have also been substituted for liquids of less inflammability, and less volatility, in industrial processes to cause fires. Sometimes the results of such substitution are highly destructive.

The use of overloaded electrical circuits, or overloaded heating appliances, has also been found effective by incendiaries in starting fires. An electric iron, without thermostatic cut-off, left on an ironing board, with the current still on the iron, may ultimately result in fire.

An overloaded electric circuit will likewise cause fire, due to the conductors becoming heated under the overload. Because the cut-off fuse protection prevents dangerously overloading circuits, the use of "jumpers" or pennies in

the cut-off box, in place of the fuse, is usually linked with overloading of the circuit.

Though eternal vigilance is the best preventative for incendiary fires, particularly those caused by the saboteur, still vigilance, no matter how faithful, will not prevent every fire of this type. Some will occur, no matter what precautions are taken. But they can be kept to a minimum by frequent inspection of a plant, insistence upon removal of rubbish, and a careful check-up of materials arriving at a plant.

California Prevention Recommendations.

The Division of Fire Safety of the State of California, in their "Report of Conference for the Purpose of Suggesting a Plan for Organization of Industrial Plants and Key Industries Against Sabotage by Fire," sets forth the following cooperation which should be extended by the municipal fire departments to industrial plants:

1. Cooperate fully with plant management.
2. Encourage joint inspection with plant personnel to guard against accidental and planned fires and explosions.
3. Familiarize public fire-department officers with all salient features of the plant.
4. Consult with management to improve fire-prevention practices and protection.
5. Cooperate with plant fire department in organizing drills, and during fires and explosions.
6. Familiarize public fire-department personnel with processes involved in the plant and with the information as how best to fight fires which occur therein.

7. Make or assist in frequent plant inspection of standpipes, first-aid fire equipment, sprinklers, auxiliary equipment, and appliances.

Conclusion.

The fire service has been fully aware of the great fire hazards brought about by modern warfare, and has been conscious of the responsibility it will have to bear if this country is brought into the world-wide conflict. Four years ago—long before the war actually started—the International Association of Fire Chiefs appointed a committee of its members to study the subject of incendiary attacks and sabotage. This committee has not only been active in the interim educating the fire service on the problems to be faced, but has cooperated with the War Department and with the Advisory Committee on Fire Defense of the Office for Emergency Management in preparing instructional material designed to strengthen the fire defenses of the nation.

Today the fire service is rapidly preparing for the work before it, and, when the call comes, it will be found ready and willing. It awaits the opportunity of matching the courage and the efficiency of its brothers in the British Isles.

Discussion.

Question. Mr. Shepperd, you described a flow of water as a cascade coming out of a building?

Mr. Shepperd. Cascading down stairways.

Question. That's right. Now, why dam that water when it will eventually flow into the sewer in the catch basin?

Mr. Shepperd. Fine, if you can so catch it, and if you get the engine suction into the catch basin.

Question. Now, on rupture of a water main, if that water main was gridded, you could isolate the rupture and divert your water through another flow?

Mr. Shepperd. Right. I was talking about a worse condition. If you have a gridiron system of water mains cross-connected at every corner and valves located at each corner so you could cut off any section the plan would be ideal. If you had a break in one section you could segregate the break and still have the system working. But a lot of you don't have cross-connections and valves, then if you have a break in a main, the far end is dead.

Question. Is it true that modern airports have a conduit to be placed on each end of the water main, that is light, and easy to handle?

Mr. Shepperd. They should have them not only at airports, but also in every fire department to serve as jumpers across open sections.

Quite recently an engineer for an airport being built in the Caribbean wanted to know about fire protection for the aprons where all the planes are parked in front of the hangars. He said it was suggested to him by someone in the War Department that they provide water heads which would cause a flow of water over the entire apron and down into a gutter. But that plan seemed to have one fault, in that in the event of a plane tank leaking and taking fire, the flowing down the apron would carry burning gas under other planes. We suggested use of fog nozzles, which

would discharge fog over the entire area. That would probably be more effective, but not 100 percent so.

Question. Do you think our greatest obstacle to surmount will be the indifferent attitude towards the emergency?

Mr. Shepperd. Very much so. Not until we are stung will we wake up. It has always been that way.

Question. Mr. Shepperd, you stated as far as London was concerned, there were 36 auxiliaries to each engine?

Mr. Shepperd. There are 25 to 30 trailers for each pumper.

Question. We are much interested in bringing that situation here at home. For example, take New York City; what did you suggest there?

Mr. Shepperd. I would say 10 to 15 trailers per company; not more than that.

Question. For each engine?

Mr. Shepperd. Not more than 10 to 15. That would be plenty because New York has many more engines and fire companies in proportion to population than London, and its area is less. You might take London's practice, and adopt it over here, but it would present several fallacies. In the first place, New York is better built than London, smaller in area, has more fire companies, and will probably never have the intensified attacks they have there, where manufacturing of bombs is done on the European continent and shipped only 40 to 50 miles to the point of use. They can't provide the same intensified bombing here with bases so far away. The difficulties of bombing, impossibility of intensified bombing, better type of building construction, large number of fire companies we have would

all make the London trailer proportion inapplicable here.

I think 10 or 15 per engine company are plenty, and probably more than we need.

Question. That's 10 to 15 trailer pumps for each engine?

Mr. Shepperd. For each engine.

Question. Take a city that has frame dwellings——

Mr. Shepperd. You need them more. You'll need all of 10 to 15 per engine company.

Question. You stated 10,000,000 feet of fire hose was manufactured in this country and shipped abroad. Can you tell us the type hose sent over there?

Mr. Shepperd. It's single jacket rubber-lined hose. But remember, London always used unlined linen hose, so this is quite a departure. I believe one of the reasons why we are not building linen hose for them now is that we can't get the linen.

Question. Can you give us any round figures in regard to hose lost in raids in London?

Mr. Shepperd. I haven't the least idea. Your guess is as good as mine.

Question. You spoke about pumping the water probably 2 miles in relay. Now, we have been informed that England has purchased single jacket rubber-lined hose. Is that hose efficient to stand the pressure?

Mr. Shepperd. Not efficient. They have had as many as 20 pumpers in line, supplying a lay-out hose. That is not efficient practice. Of course, single jacket is much cheaper and much lighter, and for the service they expect to give it, it will probably serve. You see, the hose is left attached to the hydrant all the time. They don't expect

the war to last forever, so they are not worrying about 10- to 20-year guarantees for life of hose.

But, as far as pressure goes, their trailer units are made small, with usually around 100 pounds discharge pressure, though the larger ones may give 250 pounds pressure. On the small units you can use single jacket, but for the regular service, using single jacket would not be advisable.

Question. Mr. Shepperd, do you feel our biggest problem is in educating our public in the defense proposition?

Mr. Shepperd. That's a big problem. I was at a meeting of the New York State Defense Committee recently and it was suggested that there be an evacuation of Radio City, in New York, evacuation of the Empire State Building, and evacuation of one block in Brooklyn to wake the people up to the serious problems facing us today.

Question. What is the situation in regard to these small pumps? Something tells me 4 or 5 of the companies are signed up for 6 or 8 months in advance.

Mr. Shepperd. No; that is incorrect. One manufacturer told me the other day that he could put out 1,000 in 1 month. There's nothing to worry about there. Of course, now that fire equipment has been given partial priority, there should be no difficulty getting fire apparatus.

Question. With regard to the trailer pumps, the 10 or 15 that you mentioned per engine is, of course, an arbitrary figure. On the other hand, some cities are larger than others, and the smaller cities don't have the reserve apparatus coming in. For instance, take Trenton; it covers a small territory. On the other hand, New York City has a large territory; and if they have localized bombing, they can call in local apparatus, but Trenton doesn't have that

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reserve to call upon. In my opinion, a city the size of Trenton should have a larger number of auxiliaries than larger cities.

Mr. Shepperd. I believe so, especially in areas susceptible to bombing. In New York, the large buildings are fairly fire-resistant and do not present a very severe problem. I don't believe there is any great danger of serious loss in the high-value districts of the larger cities along the coast, but I do believe that if fires get going in residential sections, such as in Queens in New York, they will wipe those places out.

Question. On the question of arousing the public, do you not believe that radio addresses would be one of the most valuable methods of doing so?

Mr. Shepperd. I believe it would be effective, but I am afraid if you concentrate on a large number of addresses at one time, an effect opposite of that desired might result. I don't believe the people are conscious of what is ahead of them.

Question. I would like to state in that connection that a great many people in this country are already aroused, and a big part of our problem might be to feed those people who are aroused some information and instructions, so that they in turn might feed it to others. An interesting and spectacular way of doing that is to have a considerable supply of these training bombs which we are using here, magnesium bombs, which simulate to all effects and purposes the kilo bombs that the Germans are now using, take those out, set them off, and show people how to put them out. That's something they could work with, and it would be interesting.

Mr. Shepperd. I fully agree with you on that. In our convention in Boston the Chemical Warfare School is cooperating with us and is going to put on a demonstration of that type. We will have 1,500 fire officers and chiefs present, and I am sure the demonstration will be widely publicized in the papers and there will subsequently be more appreciation of the dangers facing us. I believe the demonstration will go a long way in that section toward arousing the public to what is ahead of them.

Question. In recent months in Providence, R. I., which is a small city, there was conducted a survey by members of the National Board of Fire Underwriters. As a result of that survey, the impression was given through the editorials in our local newspapers that we had too much of an expense in supporting the fire department. That impression was created in the public mind. The editor of our local newspaper stressed the point on economy and cutting down the number of our force to keep it within an economical program which has been laid out by the City Fathers, so to speak.

Now, if they have created that impression in the mind of the public—understanding that this is merely our local problem—and that it has had its effect, can you tell me how a couple of small potatoes like myself are going to overcome that and arouse a new feeling such as you expect us to go back and arouse?

Mr. Shepperd. In Newark, N. J., a couple of years back, they were going to make a big cut in the fire service; in fact, they were going to abolish 12 fire companies.

The fire chief was on a spot. He called in all of his battalion chiefs who covered the sections where the fire

companies were operating, and he said, "tomorrow morning, give me a reason in black and white why each marked company should be maintained." The next morning, each battalion chief came in and gave the reasons, very good reasons. For example, an old folks' home would have no immediate protection, and they would have to wait for an engine to come up a long hill which, in the wintertime, was a slow process with ice on the hill. Similarly there was a good reason offered why each company should remain open.

So when it came to the hearing before the city council, the fire chief got up and said, "Here is the story: Company No. 14 here protects the old folks' home. There is no other company within a mile of it, and the nearest company has to go up a hill which, if the hill is coated with ice, means a 4-mile detour. If you close that station, the responsibility is upon you. I recommend it remain open." Each company had a real reason for its continuance. They closed but one company.

Many recommendations for cutting down fire protection are due to someone wanting to make a name for himself by cutting municipal expenses.

Question. Mr. Shepperd, I agree with Colonel Fisher that a way of creating public interest would be a demonstration of magnesium bombs or simulated magnesium bombs, but what is the availability of magnesium?

Mr. Shepperd. I don't know how much it would take. Probably Colonel Fisher could tell us that.

Colonel Fisher. I was asked recently to make an estimate on that. My estimate is, we should be able to turn out 50,000 a month, but as I begin to think of it I realize

that that may be small. When I gave that figure over the telephone the other day, it seemed to me like a good start.

I would like to state in that connection that we are not fighting this battle alone now. We have got a powerful man and a powerful organization behind this business in Washington, and I think it is going to go places. This course here is one indication of the fact that we are going to do things. The same office of civilian defense that has control of these matters is also hooked up intimately with the outfit that controls priorities in this country, that controls who gets magnesium. It seems to me a relatively small amount of magnesium would be necessary, and I believe those people will see it in that light and that they will see that a reasonable amount is made available for this very important purpose.

However, I am talking about something that I don't know much about and am not authorized to speak of with authority. Certain things have been suggested and I hope these matters will straighten themselves out in time. In other words, I don't think the outlook is entirely gloomy.

Mr. Shepperd. I believe that by working through the various fire organizations, including the volunteers who represent a large percentage of our small-town population, we might be able to accomplish results. I know that volunteer firemen will go to meetings a couple of thousand strong. They are interested in spectacular demonstrations, and when they go back they will carry the story back with them. I don't know whether crowds could be gotten out anywhere else for demonstrations. Possibly by working through the fire service, and particularly the volunteers, you might be able to spread the gospel indirectly, and

more quickly, than if you try to go to groups out in the field.

Question. Mr. Shepperd, is there any plan you think could be worked out for coordination between the military and civilian defense, and, in the event we are bombed, do you think we would be far better off so far as discipline and organization are concerned, if we were supervised by the military?

Mr. Shepperd. They are cooperating in that manner in England now. The British Government has given the fire service money for auxiliary apparatus and the fire service is partially under the military now. To the exact extent, I don't know. Over here, the fire service has had contact with some of the Army posts, and they advise the fire service that they will handle their own fire defense. But I believe cooperation can be developed. I believe Mayor LaGuardia, who is down in Washington, can develop cooperation if it is necessary. When the time comes, if it is found necessary, I am sure cooperation will be accomplished.

Question. Will you give us your views on the use of 1½-inch hose?

Mr. Shepperd. I am in favor of 1½-inch hose, from observation of its use. The use of 1½-inch hose, particularly in rows of attached houses, such as "taxpayers'," is invaluable. Let's take the typical example where there are four or five houses in a row all attached. A fire starts in the one in the center. You don't know which way it is traveling, and it may be going in both directions. If you come in with a 2½-inch line, and go to either side, you drive the fire the other direction. If you come in with the 1½-inch hose, using two lines you can cover the fire from both sides and put it out without its extending. It

will handle 95 percent of the fires for you. New York City doesn't use 1½-inch hose except in the outlying districts, but the smaller hose is gradually moving in.

Question. Do you think the 1½-inch hose should displace the present booster line?

Mr. Shepperd. I don't think so.

Question. Years ago, wasn't it generally recommended we carry 3-inch hose?

Mr. Shepperd. Yes; and it is still recommended that 3-inch with 2½-inch coupling, which is good practice; but such hose is chiefly for long stretches, and not for ordinary fires.

HANDLING INCENDIARIES

I want you to bear in mind, in working with incendiaries, that this is the type of work you men are going to be doing in the event of an attack. Your job is instructing the civilian population and the men under your guidance and direction in the art of handling these bombs. Incendiary fires are too small to justify calling in the fire department, and it is only when an old-fashioned fire results from incendiaries that you will be called in.

Requirements for Successful Incendiary Attack.

What do we have in our local communities that might be suitable targets for enemy attack? You must make advance preparation to meet such an attack. Some of the requirements for a successful incendiary attack by an enemy are as follows:

1. A target must have some tactical value; in other words, it must be important from a military or morale standpoint.

2. The target must be within striking distance of the weapon used to disperse the incendiaries. Back in 1917 and 1918, when grenades were used, fires could not be started at any great distance. A little later rifle grenades were used. There are definite ranges for that. And there were artillery weapons firing incendiaries such as white phosphorus. Today the most effective means of dispensing incendiaries is by plane, which necessitates computing the range of a plane. It looks as though the sky is the limit of flight.

3. The targets must be combustible. It would be very foolish for an enemy plane to drop bombs on an open field. They would not start any fires. It would not be of any great importance to drop a number of small magnesium bombs on concrete roofs previously located by reconnaissance.

4. The incendiary itself must be easily ignited.

5. The incendiary should burn with a high enough intensity to ignite the combustible material around it. It must get hot enough to set fire to things.

6. The incendiary should burn a long enough period to make certain the material with which it comes in contact is set on fire.

7. The incendiary, to be effective, should be difficult to extinguish.

8. The incendiary should be light enough so it can be broadcast wholesale, starting numerous fires. It is more effective to use a large number of small bombs rather than one large one.

9. The incendiary should be cheap enough to permit its use in large quantities, and it should be easily procured.

With these things in mind, let us proceed with the types of incendiaries, their requirements, and what incendiaries we are likely to experience.

Types of Incendiaries.

There are several incendiaries that will ignite easily. Phosphorus will ignite spontaneously. Thermit can be set off very readily with a firing charge. Our magnesium unit can be ignited fairly easily. The oil incendiary is the most difficult to ignite. The problem with oil is to have enough

of a highly volatile liquid in the oil so it will have a low flash point and will catch fire and burn readily. Some of the bombs examined abroad were found to contain nothing but crankcase oil. They did not ignite because there was not enough of the low flash point liquid in them to ignite the body of heavier oil.

Oil produces practically twice as much total heat as magnesium, surprising as it may seem; at the same time, your magnesium has a higher burning temperature. We are principally interested in getting a high intensity to start and carry on the fire so it will give off a considerable quantity of heat for a long time.

Lightness of weight, as has been said, is important in aerial dispersion. The thermit bomb is about four times as heavy as the magnesium bomb, size for size. That means that a plane which could carry a thousand magnesium bombs could carry only one-fourth as many thermit bombs. In addition to that problem there is the question of shape and container.

German Type of Bomb.

In the German type of bomb the fuse is armed. An arrangement is made whereby about 10 to 20 of these are carried in a case. There is a device which pulls 10 or 20 of the pins simultaneously, and then the bombs are all dumped. Notice the tail which is used to guide it slightly and notice that the ignition is in the nose.

As a result of this shape, however, the bomb has very poor ballistics. The bomb is not going to travel in any definite, regular course. You can't aim it at a target. All you can do is scatter out the bombs and hope that a good percentage will hit inflammable materials and get results.

The important thing about this bomb is that the entire bomb burns, except for the tail which, being of steel and iron, will not burn. This is an efficient type of incendiary, because there is very little waste.

English Type of Bomb.

Another type bomb is the English type. The bomb has a piece of iron on the nose to give it weight. There are no fins on it. There is a safety pin which is pulled in the same manner as the hand grenade. The case is made of magnesium, similar to the German bomb.

The English type bomb is hexagonal and is slightly heavier than the German bomb. Seven or eight can be put in a bundle, fitted together in a case, and dropped in bunches. The scattering effect or the spread of these bombs in falling is due entirely to the wind and the way they happen to fall out of the case. There is no means of guiding or directing the bomb.

Contents of Bomb.

For the bomb filling, the Germans have been using various mixtures. The one which is probably the oldest type is thermit, with a starting or firing mixture added to it. Thermit is iron oxide and aluminum. It looks very much like pieces of iron.

It is extremely difficult to set fire to thermit. It takes a temperature of approximately 3,000° to set it off. The starting mixture which we are using is barium nitrate. Some have used barium peroxide and have obtained the same results. Barium nitrate furnishes the oxygen just as the iron oxide furnishes the oxygen over here. Flake

aluminum and grain aluminum—it is not aluminum powder. If we used aluminum powder the action would be so violent that it would blow the shell to pieces. So, instead of using the powdered aluminum which would cause an explosion, we use the flake or grain. Just a little bit of sulfur is in there, probably to carry on the burning after it once gets started. Sulfur burns fairly readily. This mixture is called M–8.

In loading the bomb, pressed pellets are best to use—just press them in the correct size and diameter and press them down with about 500 to 1,000 pounds pressure with this M–8. Then up near the top place a small charge of "First Fire." This "First Fire" has black powder, and that black powder flash is sufficient to set fire to the M–8.

What is the purpose of M–8? It is not to cause fires because there is not enough of it to do any good. If there were, we would use something like thermit, a big 10- or 20-pound can. It is not used to injure personnel, although it does to an extent (it will shoot out 3 or 4 feet). The real purpose of M–8 is to raise the temperature of magnesium to a point where it will melt and begin to burn. The burning temperature of the magnesium shell is about 2,300° F. We have to get the magnesium burning thoroughly. So that is the function of this filling.

This is not necessarily the mixture which will be used permanently or eventually. It is one which is approved for practice at the present time. Experiments are being made continually.

Magnesium Fire.

I am going to talk about magnesium fire. There are certain hazards in connection with magnesium. After you

have found out what the hazards are, formulate your own plan for handling the particular situation. We are safe in assuming that the method Great Britain is using to handle incendiary fires is not necessarily the only way. That is the way they have found to be most successful in their situation. There may be conditions here or we may have variations in these bombs which will necessitate some changes. So let us utilize our common sense, take advantage of English experience, but attempt to improve upon their methods.

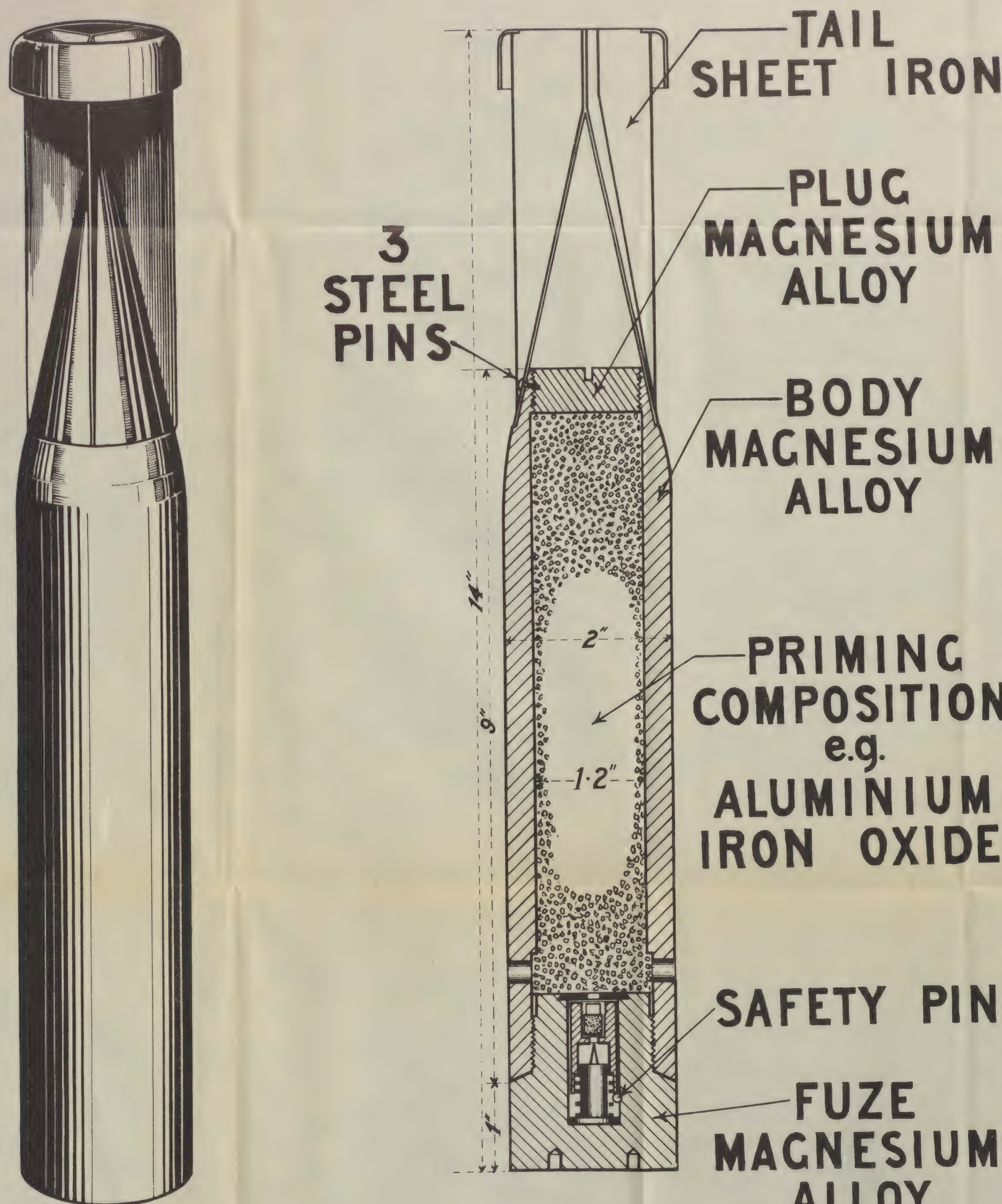
Extinguishment of Magnesium Fire.

Let us consider the various means of extinguishment that we might try on a magnesium fire. First, consider a *solid stream of water.* In burning magnesium, the magnesium grabs the oxygen from the air and forms magnesium oxide. In other words, a magnesium bomb must have oxygen. It is possible to cut off the supply of oxygen and thereby extinguish the fire.

When magnesium comes in contact with water, this action takes place:

$$Mg + H_2O = MgO + H_2$$

the magnesium is going to take oxygen out of the water in addition to getting it out of the air and is going to form the same magnesium oxide. The hydrogen which is produced is going to be loose—and you noticed recently how hydrogen, when mixed with air, explodes. If you use a solid stream of water, put it in fast and allow it to penetrate to the bottom of the burning magnesium, you can see what is going to happen. Steam is going to form down in the body of the bomb, and steam suddenly raised to a temperature of 600° or 700° will explode.



TYPICAL KILO MAGNESIUM (ELECTRON) INCENDIARY BOMB

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If we use a *spray of water or a fog,* as we sometimes call it, and put it over the surface, we are not allowing penetration of water into the bomb but merely contacting the outside surface. The action is taking place from the outside only, and we are causing action to continue. Incidentally, notice what we are doing. Magnesium is picking oxygen out of the air; that's one source of burning. Magnesium is picking oxygen out of water; that's another source of burning. Therefore, the ordinary bomb would burn from 10 to 20 minutes, depending on the surface on which it is burning. If it is burning on a sheet of iron, it will burn as long as 20 minutes. If it is burning on wooden or combustible material out of which it can extract moisture, vapors, and fumes, it may burn out in 10 minutes. But whatever time it takes, say 10 or 20 minutes, let's remember that when you put water on the burning metal it cuts down the burning time and by doubling the amount of oxygen which the magnesium has available it will, therefore, speed up the action.

What about *acid-soda extinguishers?* If we apply acid-soda to a magnesium fire, we have the same effect as a solid stream of water, because the only function of the acid and soda in that type of extinguisher is to force the water out. You have 2½ gallons of water spraying on the fire, and you are going to have a violent reaction.

What about *foam extinguishers?* Foam is a material which is aluminum sulphate, or plain alum and soda with some sort of a binder. The binder is usually tobacco juice or licorice extract. The alum and soda, when dissolved in water, will react on each other and produce carbon dioxide. The bubbles of carbon dioxide are coated with the binder which forms an impervious layer on the surface. Inci-

dentally, when this binder, which is an organic material, is heated, it will char a little bit so you will have an added effect there.

But what is going to be the effect of foam? You have to discharge it with water. What does water do on magnesium? That should answer the question.

That brings us to the next type of extinguisher, the *carbon dioxide extinguisher.* Carbon dioxide looks something like this: CO_2. Notice there is oxygen present. Magnesium has a tendency to grab oxygen wherever it can get it. Let's see what happens. The magnesium is hot and is going to take part of the oxygen

$$Mg + CO_2 = MgO + CO$$

or carbon monoxide. Would it be possible to use a carbon dioxide extinguisher in a closed, tight place if you had a burning magnesium fire? No, of course not. And if that were iron or a hot metal of any sort, it might have a tendency to rob the carbon dioxide of some of its oxygen and form CO.

Now supposing that conditions are just right, we will use twice as much magnesium. The result will be C plus magnesium oxide. In other words, there is a possibility of two different products whenever a carbon dioxide extinguisher is thrown on burning magnesium. You might have carbon or you might have carbon monoxide. Presence of carbon will be shown by some black smoke and particles floating out into the air.

Let us consider the effect of carbon *tetrachloride extinguisher.* There is a lot of argument about this extinguisher. Carbon tetrachloride vaporizes very readily. You do not get much cooling effect from carbon tetra-

chloride. Water would produce a greater cooling effect—more damage, of course. But we are not depending on the cooling effect of carbon tetrachloride. What we are depending on is the blanketing effect. There is 21 percent of oxygen in the air; cut that down below 16 percent and your fire will go out. If we vaporize carbon tetrachloride, that puts a higher percentage of carbon tetrachloride vapor in the air, and as a result we have a lowering of the oxygen concentration and subsequently the fire should go out.

There is one thing I want you to watch in the use of this extinguisher. The same thing is true of carbon dioxide or any gas which does not support life. Remember that carbon tetrachloride vapor is half sister of chloroform, and you know what chloroform vapor does in a tight place—it puts you to sleep. Carbon tetrachloride will probably do the same thing.

There is considerable argument as to whether or not carbon tetrachloride, whenever it hits hot metal, undergoes a decomposition and forms phosgene. Some of our laboratories tell us we do not get phosgene, but some men who have worked with carbon tetrachloride claim they do.

So much for that. Now, what would be the effect if we were to cover burning magnesium with *asbestos* flakes. Asbestos is a mineral which in its natural state has water tied up in it chemically. When the temperature of asbestos is raised high enough, water is exuded, causing a violent action. Therefore, I wouldn't depend on asbestos entirely as a means of smothering fire.

What about *talc?* Talc does not have the moisture in it that asbestos has, and it does a fairly good job. I think the British have been using it to a great extent. You

notice brown spots begin to form on talc when you put it on hot metal. The problem here is the availability of talc.

What about the application of *sand?* Sand is about the cheapest and most available material we have. In using sand as a smothering agent, remember it may have been subjected to rain and consequently contain moisture. If moisture is present you are liable to get some action. In addition we have this effect: Sand is silica, and silica at the high temperature of burning magnesium will react chemically. I don't mean to advise against the use of sand. Sand is available, it is cheap, and if a sufficient amount is put on the bomb, you will be able to smother it. Since sand is porous, your covering must be fairly heavy.

Now a question arises. Shall we fight the burning bomb or shall we fight the fire? That is a problem of fire fighting, of course, but I am passing it on with respect to the householder. This is a case where you must train your civilian population to use judgment. I think the rule should always be this: Never let your fire get out of control.

Safety of Personnel.

Another question. What about safety to personnel in handling this type of bomb? Possibly 1 out of 50 of the magnesium bombs may be loaded with explosives. That is one case in which we should use extreme caution. Those bombs usually explode in about 2 minutes' time. That may not be a hard and fast rule. We have a problem there that we must solve ourselves. We may hit 49—or even 50—of them without any explosive in them. Is it safe to ignore the one possibility and take a chance on not getting out? Should we use some sort of protective device

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like an asbestos blanket or shield of some sort to approach that fire?

Number of Fires.

One plane is capable of starting a great many fires. This is the same information published in *Fire Engineering,* in the N. F. P. A. Quarterly, and also in *Fire Defense.*

Magnesium bombs are used to start a large number of fires. If 80 to 85 fires are started for every 1,000 bombs dropped, the problem confronting you is obvious. In other words, it is up to the householder and the civilian to be trained in knowing how to handle those fires.

Targets of Small Magnesium Bombs.

What targets are most suitable for the small magnesium bomb? Answer: Any target which has a more or less inflammable or flimsy roof; these bombs do not have much penetrating power. Residential areas would probably suffer from this type of bomb. Magnesium bombs might do some damage in industrial areas which do not have concrete roofs. Remember that the bomb will ignite in the attic and do its job in that upper space.

Another Incendiary: The Oil Bomb.

There are two or three good types of incendiaries. One type of a bomb which is doing a good job whenever it functions is the oil bomb. A cubic foot of oil is about 2½ times lighter than a cubic foot of magnesium. It is very light, so a large quantity of oil is necessary to produce a sufficient intensity or total heat to start a good fire. In other words, if we were to make an oil bomb the size of a

2-pound bomb, we probably would not have much over a pint of oil. A pint of oil would not start a very serious fire; any housewife could handle it. The real effect of oil bombs is obtained by use of large ones. A large number of these bombs have been duds. It is a problem to get them started, but when they do work they start a considerable fire.

Now a word of caution about an oil fire. You know that if you shoot a solid stream of water down into a crater filled with oil, the oil, being lighter than water, is going to float up causing the oil to overflow and spread the fire. Never use a solid stream of water on an oil fire. One of the greatest developments that the fire service has seen in the last few years has been the vapor nozzle, or fog nozzle.

The vapor stream must be handled carefully. As the oil burns, flame rises. There is an area just above of oil vapor, gasoline vapor. There is no burning directly above the oil. There is a shortage of oxygen at that point, but when the oil vapor rises and comes in contact with the air, there is a burning effect. You can operate there with that fog-nozzled vapor stream, and just wipe the surface off. Then you have done two things: First, you have cooled down the vapor which is causing the fire; second, you have concentrated a large amount of the fog or vapor into steam and you have diluted the oxygen above the burning oil, resulting in both a blanketing effect and a cooling effect. Incidentally, whenever water changes into steam there is a cooling effect. So you have two factors which are helping to put out the oil fire.

I will mention two of the disadvantages of oil bombs: (1) Unless a light volatile oil is used, there will be difficulty in igniting it. So gasoline or naphtha or some in-

flammable material must be added to the heavy oil. In liquid form, if that oil drops any distance and the bomb bursts, there will be a scattering effect, and the chances are that scattering or spreading may take place before there is a chance to ignite the material. (2) Another disadvantage of oil is that it is fairly easily extinguished.

Now for some of the advantages of oil: (1) Probably the most important fact is that oil is cheap and abundant. (2) It has a higher heat of combustion than magnesium once it gets started. (3) Oil has a tendency to saturate a target; as a result, the burning can penetrate the material.

Variation in Oil Bombs.

There is a variation in these oil bombs. It is possible to add some material to gasoline and solidify it. For every 1,000 grams of gasoline, we would use approximately 50 grams of stearic acid and about 7¼ grams of lye, which is dissolved in about 125 cubic centimeters of alcohol. Stearic acid, lye, and alcohol are dissolved together and poured into the oil. The oil will then jell and produce a solid material. It still has gasoline in it and it will still burn. The advantage of solid oil is this: A burst produces chunks of oil rather than drops of oil spreading out and scattering, and the bigger the chunk the better the opportunity of getting intensity of heat at a particular point and setting fire to the material.

One other variation in the use of oil is the addition to this solid oil of some shavings or pieces of metallic sodium. Sodium takes fire and ignites imediately upon contact with water, generating hydrogen sufficient to form an explosive mixture. If you mix this material, use caution in adding

sodium because you may not have an oil which is free from water; you may not have an alcohol which is free from water; and you may get an evolution of hydrogen right in your hands. So be cautions in trying to make up the sodium type of oil bomb. When you put water on that type of bomb you have reignition of the oil.

White Phosphorus as an Incendiary.

One other type of incendiary is white phosphorus. The melting point of white phosphorus is low—about 111° F. and white phosphorus ignites at about 113°, or 2° higher than its melting point. Furthermore, it ignites spontaneously.

White phosphorus is an incendiary agent third in importance. It is primarily a smoke producer. Secondly, white phosphorus is a casualty agent used to produce burns. Thirdly, it is used as an incendiary. It has a very low burning temperature. It would be used most probably on thatched roofs, dry leaves, and similar materials which catch fire and burn easily. Phosphorus is the one incendiary which can be put out very readily with water. Throw water on it, either spray or solid stream, and the phosphorus goes out. However, as soon as the water drains away the phosphorus may take fire and reignite, thus causing another problem.

Standard School Lectures—
Civilian Protection
Series III

GAS DEFENSE

A. Physiological Effects and First Aid.
B. Protection of Supplies, Equipment, and Food.
C. War Gases—Physical and Chemical Characteristics.
D. Persistent and Nonpersistent Gases.
E. Protection Against War Gases.
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G. Noncombatant Masks.
H. Care, Storage, and Disinfection of Gas Masks.
I. Gas Mask Drill.
J. Gas Chamber Field Exercise.
K. Protective Clothing.
L. Decontamination.
M. Collective Protection—Gasproof Shelters.
N. Noncombatant Mask, Chart.
O. Army Training Mask, Chart.

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ABOUT THESE NOTES

These lecture notes, taken at the first Civilian Defense Course at Edgewood Arsenal, Md., are offered for the use of instructors in local schools. They are fairly complete transcriptions of the lectures as given, except that restricted or confidential matter has been eliminated, and the lectures have been somewhat shortened.

For the convenience of instructors, they are presented in series so that all pertinent material may be assembled in one place, together with any notes the instructor wishes to prepare himself.

Attention is called to Lecture on Organization and Conduct of Local Schools, in series II. This lecture deals especially with expedients and methods of dramatizing instruction; it is included here, not as the material for a lecture to be given by instructors, but for their reference in planning courses.

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IIIA

PHYSIOLOGICAL EFFECTS AND FIRST AID

I will discuss first the effect of chemical agents on the human body; next, how that action takes place; and then, in fairly nonmedical terms, first-aid treatment.

The Medical Corps classifies the injurious action of agents on the human body according to a physiological classification. There are (1) lacrimators, or tear gas—that produces tears; (2) irritant smokes called sternutators—the British term is "sneeze gas"; (3) lung irritants like phosgene and chlorine, which affect the body when breathed into the lungs; (4) vesicant agents which produce blisters and burns—the British call them "blister gas"—prime examples are mustard and lewisite; (5) systemic poisons, sometimes called paralysing agents; when they get into the body through the lungs, they affect the entire body rather than irritating one part such as the lungs; (6) finally, there are incendiary agents which produce fires and burning. Incendiaries are rarely used for effect on personnel.

In considering a particular agent we sometimes consider only its main, or most-used action, but an agent may act in more ways than one.

INCENDIARY AGENTS

Let us start with the incendiary agents. The ordinary incendiary, such as thermite, and the oil incendiaries simply cause heat plus burning, which fact you already know. The first aid is the same as that used for any burn.

One exception, however, is *white phosphorous.*

White Phosphorus.

White phosphorus produces a heat burn, but it also has properties of its own. It reignites itself. Any ordinary fire, when it has water poured over it, can be put out. Burning oil can be put out. White phosphorus is different. The minute air gets to white phosphorus after it has dried, it reignites and burns again. A particle of white phosphorus on the clothing or skin can be put out for the time being with water, but the minute the air gets to that particle again it reignites and continues to burn. The effects of white phosphorus are the same as of a heat burn. But the treatment of white phosphorus differs from an ordinary incendiary in this manner: If you have no other means on hand you must keep the person wet; the affected part must be washed and kept wet until the particle can be dug out of the skin. If water is available, keep the wound under warm water and cover with wet cloths.

It used to be said that the injured part should be covered with mud if water were not available, but the mud of a battlefield is dangerous from the standpoint of infection. Urine is sterile, and certainly far preferable from a medical standpoint to putting mud on white phosphorus burns. Use it rather than mud regardless of the source.

First Aid for Phosphorus Burns.

The first thought in first-aid treatment of phosphorus burns is to keep the injured part wet with water; next, if available, to put the part, such as the arm, under water heated to about 40° C. (104° F.); that is, good warm water

to melt the phosphorus. Wash the wound lightly, and then attempt to squeeze out the remaining particles. You will have to use forceps to pick out the particles if you cannot keep the affected part in water. It is easier to squeeze these particles out than to pick them out. This is primary first aid.

A more specific first-aid provision for phosphorus burns is a solution of copper sulphate. Upon contact with phosphorus, copper sulphate forms a precipitate that prevents air from touching the white phosphorus. If you cover up the part with a copper sulphate solution, you get a thin dark skin on the particle of phosphorus which is airtight, and you can then handle the particle like a grain of sand. Of course, you have to use common sense; you must not handle the wound too roughly. The strength of copper sulphate is not important—anything from 5 to 10 percent—or enough copper sulphate to make the water good and blue—is enough. In organizing first-aid stations, the best thing to have available would be saturated solutions (about 40 percent) of copper sulphate. This solution could be reduced by mixing one part saturated solution to three parts of water. This solution may be applied with cloths, or poured over the affected part which is covered with cotton. The wet cotton should be allowed to remain until the particle can be removed from the skin. Further treatment of a white phosphorus burn is exactly the same as first aid for any other heat burn.

VESICANTS

Next we shall discuss vesicants, such as mustard, the chemical warfare symbol for which is HS.

The human skin consists of two layers. The outer skin, or epidermis, is largely dead cells corresponding to your fingernails or hair. Underneath that is the dermis skin, through which the blood vessels run. The dermis contains the oil glands. Mustard acts on both layers.

Mustard.

Mustard is rapidly absorbed in the skin. A drop falling on the skin will be seen for a minute or two in a glistening area of dampness. Then it penetrates rapidly and disappears into the skin. With liquid mustard nothing happens after that for a period of 2 to 6 hours. A vapor burn may not show any symptom for as long as 12 hours, and the skin experiences no effect whatever.

In this delayed action, mustard resembles sunburn or X-ray exposure. There is no effect for a period of from 2 to 6 hours, depending upon the person's sensitivity. The first symptom is reddening of the skin in the area exposed. The redness is due to the primary effect of the heat of the blood vessels in the lower area of the skin. The medical term give to this stage is "erythema." Soon these irritated blood vessels are affected so that the blood serum rises through the dermis skin, and we have the stage of "raised redness." Later this escape of fluid from the blood vessels goes on and on, and finally in the separating of a layer of the upper skin from the lower dermis skin we have developed a blister. Thus there are three stages: The redness, the raised redness, and the blister.

A blister will go through all three stages. First there is the redness or raised redness, later the actual death of the skin cells, and finally the ulcer. The action is very much the same as that you get from sunburn. After the

blister is gone, a brownish pigmentation is formed which lasts for several months.

One of the astonishing things about this mustard burn is that there is no pain involved. I know of no other chemical or physical agent than can cause as much damage—without causing pain. But mustard burns do itch. In the case of light mustard burns, look into the use of anti-itch ointments. This is not exactly first aid, but it is important.

Mustard in the Eye.

There is one striking exception to pain, and that is mustard in the eye. Either liquid or vapor mustard in the eye is immediately very painful. Vapor burn in the eye feels like a grain of sand in the eye and causes smarting. Eye burns cause an increased flow of tears and consequently the outer surface of the eyeball becomes glazed over. It looks like ground glass instead of crystal-clear. The important thing to remember, from a first-aid point of view, is to keep the person in darkness, but *not* to bandage the eye. Give frequent washing with boric acid and reassure the patient that he is not going blind. We had a great number of mustard vapor burns in the eye during the last war, yet blindness resulting from gases represented a very negligible percentage.

The Eye Will Recover.

A drop of mustard in the eye is different and much more serious. There is a great deal of pain, and liquid mustard burns form an ulcer on the eye. Vision is permanently affected. The patient can recognize light and dark, but

cannot form a sharp image. It is like looking through corrugated glass.

For liquid mustard in the eye, the first aid is repeated washing out; there is nothing better than plain water. You can use boric acid, but not borax. You can use sodium bicarbonate, but *NOT carbonate of soda.* Put a spoonful of boric acid or sodium bicarbonate in a glass of water and then wash out the eyes every 5 minutes for hours. First aid for the eyes is not as satisfactory as one would like. Mustard in the eye is bad and we know it.

First Aid for Vesicants on the Body.

Now for first aid for other parts of the body. For any of the vesicants the time element is of the greatest importance. If you can get at mustard within the first 5 seconds after it contacts your skin you can effect the proper treatment with almost anything—even with soap and water. If not for 15 minutes, the cards are stacked against you no matter what you use. Each second's delay means that much more against you.

There are two general methods of first aid for mustard burns aimed at the removal of the mustard from the skin. One is by dissolving the mustard out of the skin. The other is by using something that will neutralize or alter it so it will not cause damage.

Solvent Method.

The solvent method is the one most generally applicable. Mustard is soluble in alcohol, kerosene, carbon tetrachloride, and gasoline. Any of these may be used, depend-

ing on what is available, but motor gasoline contains tetraethyl lead and should not be used unless nothing else is at hand. The important thing in the solvent removal of mustard from the skin is to remember the way to use it.

Each second that mustard is in contact with the skin, it is penetrating into the skin and doing damage. All you can do after 5 seconds is to prevent further damage. Limit the area. A drop is more than enough to damage the skin. If it is diluted and spread, you get a blister—and a big blister. Remember to dissolve that spot and do it without spreading. This requires a special technique.

First get a dry cloth of gauze or cotton waste, and blot the burn. Throw that cloth away. Then take a cloth that is simply damp in the solvent, not wet or soaking, apply it, press it firmly, and throw it away. That solvent has penetrated and you have gotten rid of some mustard. Continue each time taking a fresh piece of cloth, damp with solvent, putting it on, pressing it, and throwing it away. Do this four or five times. You are then doing as much as you possibly can. If you can start within 15 seconds after the mustard contacts the skin, you can prevent most of the damage. It is equally important to destroy the cloths that are thrown away. They have mustard on them and can do damage. They should be gathered up and buried, or burned in such a way that the smoke, which will carry mustard vapor, will not cause injury. Do not leave them lying around. One thing I do not like about solvent removal is that it may be done by people who do not understand the danger of it and who may cause additional harm by spreading the liquid over the skin. It is a good method if used with proper care.

Destroying Mustard in Place.

The second method of first aid consists of destroying the mustard in place. Almost all of these methods for mustard depend upon adding chlorine to the mustard. Mustard has 2 chlorine atoms in 1 molecule. The adding of chlorine to mustard chemically can only be done by providing active chlorine. A common material that gives off chlorine in active form is bleach—chloride of lime or calcium hypochlorite. "Bleach" is the chemical warfare term. For use on the skin, you take dry bleach and make up a thin paste with it. Proportions don't matter—one part bleach and one part water; or one part bleach and two parts water—so long as you get a thin paste. Apply this to the skin and wash it off thoroughly. It is irritating, but less irritating than mustard. If you put dry bleach on the skin, you will get a heat burn because dry bleach ignites mustard, thus causing additional damage. If I had mustard on me from airplane spray, and I had bleach but no water, I would put the bleach on and take a heat burn in preference to the mustard burn. For first-aid work, any sort of bleach and water preparation you can make up can be used. It is preferable to destroy mustard by bleach rather than by the use of solvents, if bleach is available.

Protective Ointment.

I want to mention a third method. We now have an ointment that will protect against saturated mustard vapor for 3 hours. It is by far the best known preparation to remove mustard from the skin. If you have mustard on the skin, either vapor or liquid, put this jelly on and rub

it off. Repeat this procedure, then wash with soap and water. It is now a standard item of chemical warfare material—the same as the gas mask. I don't know if this item will be made available to civilian defense. It is put up in 3-ounce collapsible tubes for each soldier to carry. It is intended primarily for skin that cannot be protected. It is not ideal—just a dirty, sticky mess on your skin that picks up the dirt—but it does protect against mustard.

Summary of First Aid Against Mustard.

Now for a very brief résumé of first aid against mustard. Speed is important. One method of treatment is solvent removal by means of solvents. I also have emphasized need of care and discriminate washing. Another method is the neutralization with bleach or chemical warfare ointments. Their composition is at present a secret. I have no idea about their availability outside the Army.

Another Vesicant: Lewisite.

I want to mention the other type of vesicant: M-1, or lewisite. We know mustard from the last war. We know it is going to work. That makes mustard valuable. Lewisite has never been used in warfare.

Experimental work on lewisite and mustard has to be done on animals. No animals produce blisters with mustard. We don't know as much about lewisite as we would like. Lewisite not only is a vesicant but it contains arsenic. Arsenic, remember, is a general poison; so we not only have local effects similar to mustard but have also general effects throughout the body such as on the kidneys and liver. One cubic centimeter, or one-thirtieth of an

ounce, on the skin of a man (or animal) will be sufficient to kill him from the arsenic he would absorb. It is hard to kill a man with mustard; he will recover. You can have a comparatively small burn with lewisite, and it will have grave, if not fatal, effects, due to the arsenic absorbed. For that reason speed in first aid for lewisite is even more important than mustard.

The effects of lewisite are similar to that of mustard, with the exception that lewisite effects are much quicker. The effects from mustard are noticeable in from 2 to 6 hours. You see redness from lewisite in 15 seconds after the drop hits you, and it is painful. It aches rather than burns. There is a difference between mustard and lewisite burns which might come in handy if you don't know which agent is used. A mustard blister is surrounded by an area of redness which fades out. In the case of lewisite, the blister comes out sharply to the edge of the inflamed reddened skin. This is a point that may be of use if you don't know what agent has been used.

There is a further difference; the blister fluid from lewisite will cause other blisters; not only that, you must get rid of it to prevent arsenic from being absorbed in the skin. Those are the differences between lewisite and mustard: Quick redness forms; painfulness; blisters will do harm. And you must get rid of the blister fluid in a lewisite blister because of the arsenic present.

First Aid for Lewisite.

Now as to first aid for lewisite. You can use the same solvents with the same precautions as for mustard. It has the same advantages and all of the draw-backs. The

chemical neutralization is different. To remove lewisite from the skin the Medical Department of the Army recommends for Army field use:

	Parts
Sodium hydroxide	10
Glycerine	30
Water	60

We have known for years that 10 percent sodium hydroxide to remove lewisite from the skin gives as good a burn as lewisite. A dermatologist suggested glycerine to protect the skin. We found that glycerine protected the skin but didn't protect against lewisite.

More recent work shows that hydrogen peroxide—drug-store peroxide—is more effective and that there is less possibility of harming the skin than in the case of the sodium hydroxide solution. It is the only thing that can be used for lewisite in the eye. It is the thing to use on the skin. For use in the eye, dilute drug-store peroxide with water; use it undiluted for the skin.

Further treatment of any of these vesicant injuries is the same as for any heat burn. We advocate tannic acid treatment for the blistered area. You have been taught the treatment of the heat burn and use of tannic acid, 5 or 10 percent. The British are using 5 percent tannic acid and 5 percent silver nitrate, and then the dye.

SYSTEMIC POISONS

Next, I want to take up briefly the systemic poisons. Examples are hydrocyanic acid and carbon monoxide. The use of hydrocyanic acid as a war agent is very doubtful.

Hydrocyanic Acid.

When absorbed into the blood stream, hydrocyanic acid shuts off the ability of the tissues to use the oxygen from the blood. The red blood corpuscles go to the tissues, give up oxygen, and come back to the lungs for another load. Hydrocyanic acid prevents the release of oxygen into the tissues. The results are usually very quick. The symptoms are usually a feeling of tightness, like a band around the head; very rapid dimming of consciousness; unconsciousness; convulsions; and death.

Cyanide is not nearly so poisonous as we usually think. It occupies about the same place as leprosy does in communicable diseases. Everybody has a horror of leprosy, but of all communicable diseases leprosy is the hardest to contract. I think much the same way about cyanide. However, cyanide usually kills you at once or there is quick and complete recovery. From the first-aid point of view there is very little that can be done. If the patient is unconscious, use artificial respiration and give amyl nitrite. Amyl nitrite is sometimes known as pear oil. It comes in little glass pearls that you break and inhale. That is the only thing I can recommend: The inhalation of a pearl of amyl nitrite; and, if the patient is not breathing, artificial respiration.

Carbon Monoxide.

Of much more importance as a general poison is carbon monoxide. Carbon monoxide probably never will be used as an agent. It acts like cyanide to cut off oxygen from the body—but at a different place. Carbon monoxide goes into the red blood cells and forms a combination there that is

more stable than their combination with oxygen—300 times more stable. Carbon monoxide destroys much of the oxygen-carrying power of the blood. The symptoms are slower in developing than cyanide but are in much the same order: A headache develops slowly which is a very characteristic type—it feels as if an iron band were being tightened about the head—and sometimes the person is unable to see clearly.

The first aid for carbon monoxide is to get the man out of the contaminated atmosphere quickly, give him artificial respiration if he's not breathing, and supply oxygen. Atmospheric air is only 20 percent oxygen. If you can use 100 percent oxygen you have increased your chance by 5 to 1. Thus the treatment is artificial respiration and oxygen administration, if available. I might say that not only automobile exhaust but high explosives, the products of explosion, all have a very high percentage of carbon monoxide in them. There is always danger that gases from explosion will seep through debris or in mining operations in warfare. People taking refuge in shell holes have been affected by the carbon monoxide that seeped through a good many feet of dirt to reach them. People buried under debris have some chance of breathing the carbon monoxide remaining from the explosive gases that may be trapped within the remains of the dirt.

IRRITANT SMOKES

Coming to the class of irritant smokes, or sternutators, we have DM and DA. They are the sneeze gases or irritant smokes. They are not gases or vapor, but are fine particles floating in the air. An apt description of how they

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affect you: If you had sinus trouble, a toothache, a headache, a bad cold, bronchitis, and seasickness, all at the same time, you would have a good idea of how these irritant smokes affect you. You become terrifically sick, but the effect is temporary.

The first-aid treatment, when you have the man out of the gas, is to keep him away from heat. The smoke will be on his clothing and will vaporize again. Let him breathe fresh air. Possibly the most effective treatment is to have a very weak concentration of chlorine. Take a handful of dry bleach powder in an old can and let him sniff the very weak concentration that comes up from the can. It does work. Another method is spraying the nose with any adrenaline nose sprays that are on the market. Rest, a couple of aspirin tablets for the headache, and in 5 or 6 hours a man will be back to normal. There have been cases of people trying to do injury to themselves; they feel so sick they are actually in delirium. Anyone exposed to a high concentration should certainly be watched to see he does not do himself injury.

LUNG IRRITANTS

Last of all, I will discuss briefly the lung irritants, for example, phosgene. Anything that can burn your skin will also injure the far more delicate structure of the lungs.

The surface area exposed to gas in the lungs is enormous. There are 130 square meters of surface in the lungs. This is about 100 times the skin surface available for injury.

Each of the different lung irritant agents shows its greatest effect at a different level in the respiratory tract.

Chlorine.

A very high concentration of chlorine has been known to cause instantaneous death after the first breath of it. This is probably from reflex action. In the concentrations usually encountered in the field there is first caused a spasm of the bronchial tubes. This causes violent coughing and distress, but gives some protection in preventing the chlorine reaching the depths of the lungs. The effects are mainly ulceration and inflammation, limited largely to the upper respiratory tract.

Phosgene.

Unlike chlorine, phosgene in usual field concentrations is not irritating and is therefore breathed into the most distant part of the lungs—the delicate alveoli. Here it combines with the moisture present to form hydrochloric acid. This acid injures the delicate cells lining the alveoli and the capillaries and the injured cells allow the fluids of the blood to pour out into the lung units. This is what is meant by lung edema. The fluid fills these lung units and, if it continues, the man drowns. He drowns in his own body fluid—but he drowns just the same. One particularly dangerous feature of this is that these symptoms may be delayed for hours. A man may be in a very dangerous atmosphere of phosgene and show no immediate effects. He can go along for 6, 12, or 18 hours, until some exertion causes him to cough. Within a half hour he is a sick man and he will be dead in 2 hours. We know very little about what causes this delay. What we are certain of is that the one thing that will bring on the rapid development is exertion.

For first aid in lung edema cases, we must have rest, warmth, and oxygen. Of these three, by far the most important after exposure to a lung irritant is absolute rest. The patient must not walk; he is to be carried as a litter patient and kept quiet. Warmth we insist upon, because if a man is cold and shivers he is going through the equivalent of considerable exercise. And finally, oxygen. Instead of giving a man the 20 percent oxygen in air, we must try to supply 100 percent oxygen, which may get through the water in his lungs and help to support life.

Mustard as a Lung Irritant.

Finally, let us consider mustard as a lung irritant. Mustard does not produce lung edema as just described. It produces ulcers in the upper respiratory passages very similar to the ulcers produced on the skin. These ulcers allow infection to enter the lungs and a septic pneumonia results. Ninety-five percent of deaths from mustard in the World War were due to this pneumonia. You know of the success in recent years in the treatment of pneumonia with sulfonamide drugs. We believe these sulfonamide drugs will be just as useful in treating pneumonia from mustard.

Much less is known about the effects of lewisite in the lungs. It does not produce the same pneumonia as mustard. The effects are largely that of arsenic in the lewisite.

The first aid for the effects of inhaled mustard is largely prevention. In other words, the gas mask. The principles of rest, warmth, and oxygen also apply.

IIIB

PROTECTION OF SUPPLIES, EQUIPMENT, AND FOOD

During the gas attack, all possible cover should be given to equipment and supplies. The clothing of personnel, if contaminated, must be removed and decontaminated. The Army provides demustardizing companies, mobile bathing units; some such organization may be needed for civilians. Clothing contaminated by mustard gas can be decontaminated by long periods of exposure to sun and wind, by steam, or by treatment with chlorine. In some cases it may seem advisable to destroy materials which have been too badly mustardized. The time and expense involved in cleaning them up is not worth the risk.

Weapons, ammunition, and vehicles which are subjected to gas attack will require thorough cleaning. No time should be wasted in starting the clean-up of such equipment. The methods of decontaminating various items will be discussed later.

Ordinary paint is quickly penetrated by vesicants, while nitrocellulose lacquers are highly resistant to mustard. Cellophane has been mentioned as being good protection and even heavy paper, such as building paper, will afford temporary protection against vesicants sprayed from airplanes. Chemicals used for decontaminating will probably remove paint, but that is the price which must be paid to rid the article of mustard.

Food.

The protection of food and water requires maximum consideration. Not much progress has been made in treating foods which have actually been contaminated. In most cases any food which has been in direct contact with mustard gas must be destroyed. Canned foods are safe because the cans can be dipped in a decontaminating agent, noncorrosive, or treated with steam or hot water. Cellophane-wrapped foods in individual packages and small cartons of frozen foods, such as those put out by the Birdseye process and wrapped in cellophane, may be one answer to this problem.

Food depots, slaughterhouses, cold-storage plants should be as gastight as possible. Wherever practicable, the food should be in tin or airtight containers of some other sort. Porous foods that are contaminated should be destroyed. Flour that has been contaminated will make poisonous bread even after the baking process.

Water.

Water supply is of vital concern since many communities obtain their water from reservoirs open to air attack. Water contaminated by lewisite (M–1) is unfit to drink. There is no known method of purifying that water. Lewisite is rapidly destroyed by water, but leaves behind a product which is just as poisonous as the original lewisite. Water contaminated by mustard is in a different class. Liquid mustard will settle to the bottom of a pond of water and there will slowly decompose over a period of months or

even years. The decomposed products of mustard are non-poisonous so water withdrawn from an in-take pipe well above the bottom of the reservoir will probably not be harmful.

Remember that forage of animals must be as carefully protected as food for humans. Any forage which is suspected had best be destroyed.

IIIC

WAR GASES
PHYSICAL AND CHEMICAL CHARACTERISTICS

We shall start off by saying what is meant by a chemical agent. This is a better term than poisonous gas because many of the materials used in chemical warfare are not poisonous, and most of them are not gases.

A chemical agent is a substance used in war, which by its ordinary direct chemical action produces one of three things: A powerful physiological effect, a screen smoke, or an incendiary action.

Now we still use the word gas, though rather loosely, to designate those chemicals that have a physiological effect. Their main purpose is to obtain a physiological effect. We still speak of them generally as gases even though they may not be gases.

Questions Frequently Asked.

We in the Chemical Warfare Service are asked frequently two things. First, why hasn't gas been used in the present war in Europe? Our answer is that chemicals have been used right along.

The second question is: What danger is thereof of a new gas or a new agent being used against which we have no protection? Well, we cannot answer that positively, because we never know the other fellow's secrets. But we can say definitely that the chances are rather slim of any enemy using a new material against which we have no protection.

There are several reasons for that. One is that a tremendous number of chemicals and compounds have been investigated for possible use as chemical agents, and very few have been found satisfactory. You can count all of the important war chemicals on the fingers of your hand, yet over 300,000 compounds have been studied; so you see the requirements are very strict before the material can break over into a selected group of accepted chemical warfare agents, or gases if you please. Second, any material that might be introduced as a chemical agent in war will probably resemble some known gas, and will fit more or less into our present scheme of classifications. So it is important that we have some system of classifying these chemical agents, and that is one thing that I want to take up. In the next period, I will take specific examples and tell you more detailed facts concerning them.

Classification of Chemical Agents.

One of the simplest ways of classifying chemical agents is according to whether they are liquids or gases. The *temperature* that we assume usually is 68° F. If something is a gas at that temperature, we say that is a gas. If we say it is a liquid, it is a liquid at that temperature. Now air is a mixture of gases. Water is a liquid. A piece of chalk is a solid. The only important thing to remember on that basis of classification is that none of the agents is a gas before it is turned loose. All agents are all either liquids or solids before release. After release, they may be either gases, liquids, or solids.

Another simply way of classifying agents is by what we call their *persistency.* Persistency means the time that a

material will remain effective after it is turned loose. Persistency may last from 5 minutes to 6 months.

Let us digress for a moment and I will try to give some of the reasons why there is chemical warfare. There are a couple of things that you can do with chemical agents that you cannot do with rifle fire or shell fire of any kind.

First, you can "fire around corners" with chemical agents. If we have a target and there is a big steep hill, or a long ridge between our guns and the target, we can fire our shells so they will burst somewhere where the hill doesn't bother us, and yet the wind can blow the chemical agents down on the target. What have we done? You might say we have fired at right angles.

Another reason for chemical warfare is that you can have a continuing effect over a long period of time with a very small amount of material. A few mustard shells fired on a target may make the area dangerous for months.

Now to return to the classification of chemical agents. These can be classified according to *persistency.* Chemicals are broken down into two classes, persistent and nonpersistent. The time limit between the two classifications is an arbitrary figure which we have set up to be 10 minutes.

If I turn loose a chemical agent on the golf course and I can walk back in that area in 10 minutes without any bad effect on me, the material was nonpersistent. If it remains dangerous for 10 minutes or longer, it is a persistent chemical agent.

The most common way, however, of classifying chemical agents is according to the most pronounced *physiological effect.* By a powerful physiological effect, I don't mean that the man has to die. If he doesn't do anything except

cry violently and copiously, that is a powerful physiological effect.

Breaking chemical agents up into groups according to physiological effect, there are lung irritants—lung injurants is a better word because most of these things do more than irritate; vesicants; lacrimators; and irritant smokes.

Screening smoke and incendiaries also have some physiological effect, but that isn't their primary purpose. In contrast, the primary effect of gases is irritation or injury to the breathing parts of the body.

A vesicant is a blistering agent. That is what the word means. If the material will blister the skin of a man, certainly it will blister his lungs, so that vesicants will also irritate the lungs. However, lung irritants won't bother the skin.

Lacrimators are tear gases. The irritant smokes are given that name, too, to separate them from the screening smokes, and the name then is significant. These materials affect a man physiologically, and the screening smokes do nothing except just hide something.

Properties of Chemical Agents.

Chemical agents must have certain properties.

First, they must conform to the definitions that I gave you a little while ago, otherwise they are thrown out immediately.

Second, to be useful as a chemical agent in war, a material must be capable of being dispersed by air. We use the air almost entirely as our medium for dispersing these materials.

Third, the material must be stable in storage, and upon dispersion in the field. Large supplies must be built up and kept on hand. Also, raw materials must be available in required quantities, preferably within the continental United States. Chemical agents must not be so corrosive that ordinary steel will not suffice as containers or as munitions. Containers have to be lined with lead or glass or porcelain to store certain materials satisfactorily. If the agent is a true gas, it must be easily liquefied. We have to be able to compress a large amount of material into small space in order to transport it easily. Phosgene in gaseous form on a hot summer day will occupy a lot of room, yet it is rather easily compressed from a gas to a liquid.

A material to be a successful agent must be one against which protection is difficult. Mustard gas is a good example. Chlorine is no good because the enemy can easily protect himself against it. Another essential requirement is that the vapor of the material must be heavier than air. Carbon monoxide is not a successful chemical agent because it is lighter than air. Turned loose on the battlefield, it will go straight up, and it doesn't stay around long enough to do any harm. Hydrocyanic gas is lighter than air also and must be confined to be effective.

All of the successful chemical agents that we talk about from now on have those properties. They are easy to make. They are satisfactory in storage and they are difficult to protect against and so on.

There are several other definitions of properties that we study. We speak about the vapor density. That is the weight of the vapor compared to air. The material should

weigh more than air. When we say the vapor density of a material is 2, we mean it is twice as heavy as air.

Another property is solubility. When you dissolve a substance in water you are taking advantage of the solubility of that substance in that liquid. We test the solubility of all of these various materials and we find out whether they can be put into water so they can be used in liquid form if they are already liquids. Sometimes we want to find out whether agents will mix or not so we talk about the solubility of these various things. We want to know also what effect water has on the chemical agent, and we speak about a term which might be a little bit new, that is "hydrolyze," which means it reacts with water. When we say a material is stable in hydrolysis, it means that it is not affected by the water and water doesn't destroy the material.

Water will destroy certain of these agents but it will have no effect on others so we talk about their stability or their instability—about hydrolysis, that is, whether an agent will resist water or succumb to it.

We talk about some other properties. We will try to define them as we go along.

Now I will show you a chart which classifies chemical agents according to liquids and gases, according to persistency, and also the physiological effect.

Identification of Chemical Agents by Odor.

You are going to hear a lot about the *odors* of some of these chemical agents and about identifying them.

First, why do we need to be able to identify chemical agents that might be used against us? The answer is, we

REFERENCE AND TRAINING CHART

CHEMICAL WARFARE AGENTS

PREPARED BY OFFICE OF CIVILIAN DEFENSE

CLASS	NAMES AND SYMBOLS	FORM	ODOR	PHYSIOLOGICAL EFFECT	TACTICAL CLASS	PROTECTION	FIRST AID [After removal from gassed area]	PERSISTENCE	FIELD NEUTRALIZATION
VESICANTS	MUSTARD $S(CH_2CH_2)_2Cl_2$ DI-CHLORETHYL SULFIDE	LIQUID AND VAPOR	Garlic, Horseradish, Mustard	Delayed effect. Burns skin or membrane. Inflammation respiratory tract leading to pneumonia. Eye irritation, conjunctivitis.			Undress; remove liquid mustard with protective ointment, bleach paste, or kerosene; bathe; wash eyes and nose with soda solution.	One day to one week. Longer if dry or cold.	Cover with unslaked lime and earth. 3% solution of Na_2SO_3.
VESICANTS	LEWISITE $CHClCH\text{-}AsCl_2$ CHLORVINYL-DICHLORARSINE	LIQUID AND VAPOR	Geraniums	Burning or irritation of eyes, nasal passages, respiratory tract, skin. Arsenical poison.			Undress; remove liquid Lewisite with hydrogen peroxide, lye in glycerine, or kerosene; bathe; wash eyes and nose with soda. Rest—Doctor.	One day to one week. Longer if dry or cold.	Wash down with water. Cover with earth. Alcohol. NaOH spray.
VESICANTS	ETHYLDICHLORARSINE $C_2H_5\text{-}AsCl_2$	LIQUID AND VAPOR OR GAS	Stinging, like pepper in nose	Causes blisters, sores, paralysis of hands, vomiting. Severe on long exposure.			Undress; remove liquid with hydrogen peroxide, lye in glycerine, or kerosene; bathe; wash eyes and nose with soda. Rest—Doctor.	One hour.	Cover with earth, caustic.
LUNG IRRITANTS	CHLORINE Cl_2	GAS	Highly Pungent	Lung irritant.			Remove from gassed area. Keep quiet and warm. Coffee as stimulant.	10 minutes.	Alkaline solution.
LUNG IRRITANTS	CHLORPICRIN CCl_3NO_2 NITROCHLOROFORM	GAS	Flypaper, anise	Causes severe coughing, crying, vomiting.			Wash eyes, keep quiet and warm. Do not use bandages.	Open 6 hours. Woods 12 hours.	$NaSO_3$—Sodium sulfite in alcohol solution.
LUNG IRRITANTS	DIPHOSGENE $ClCOOC\text{-}Cl_3$ TRICHLORMETHYL CHLOROFORMATE	GAS	Ensilage, Acrid	Causes coughing, breathing hurts, eyes water, toxic.			Keep quiet and warm. Give coffee as a stimulant.	30 minutes.	Alkali.
LUNG IRRITANTS	PHOSGENE $COCl_2$ CARBONYL CHLORIDE	GAS	Musty hay, Green corn	Irritation of lungs, occasional vomiting, tears in eyes, doped feeling. Occasionally symptoms delayed. Later, collapse, heart failure.			Keep quiet and warm, bed rest. Coffee as a stimulant. Loosen clothing. No alcohol or cigarettes.	10 to 30 minutes.	Alkali.
LACRIMATORS	CLORACETOPHENONE $C_6H_5CO\text{-}CH_2Cl$	GAS	Apple Blossoms	Makes eyes smart. Shut tightly. Tears flow. Temporary.			Wash eyes with cold water or boric acid solution. Do not bandage. Face wind. For skin, sodium sulphite solution.	10 minutes.	Strong, hot solution of sodium carbonate.
LACRIMATORS	BROMBENZYLCYANIDE $C_6H_5CH\text{-}BrCN$	GAS	Sour fruit	Eyes smart, shut, tears flow. Effect lasts some time. Headache.			Wash eyes with boric acid. Do not bandage.	Several days. (Weeks in winter.)	Alcoholic sodium hydroxide spray.
STERNUTATORS	ADAMSITE $(C_6H_4)_2\text{-}NHAsCl$ DIPHENYLAMINECHLORARSINE	GAS	Coal Smoke	Causes sneezing, sick depressed feeling, headache.			Keep quiet and warm. Loosen clothing. Reassure. Spray nose with neo-synephrin or sniff bleaching powder. Aspirin for headache.	10 minutes.	Bleaching powder solution.
STERNUTATORS	DIPHENYLCHLORARSINE $(C_6H_5)_2\text{-}AsCl$	SMOKE	Shoe Polish	Causes sick feeling and headache.			Remove to pure air, keep quiet. Sniff chlorine from bleaching powder bottle.	Summer 10 minutes.	Bleaching powder solution.
SMOKES	H C MIXTURE $ZN + C_2Cl_6$	SMOKE	Sharp-Acrid	Harmless.		None needed.	Produces no effect requiring treatment.	While burning.	None needed.
SMOKES	SULPHUR TRIOXIDE $SO_3 + SO_3HCl$ IN CHLORSULFONIC ACID	SMOKE	Burning matches	Causes prickling of skin, flow of tears.			Wash with soda solution.	5 to 10 minutes.	Alkaline solution.
SMOKES	TITANIUMTETRACHLORIDE $TiCl_4$	SMOKE	Acrid	Harmless.		None needed.	Produces no effect requiring treatment.	10 minutes.	None needed.
INCENDIARIES	WHITE PHOSPHORUS P	SMOKE	Burning matches	Burning pieces adhere to skin, clothing.		None needed.	Pack in cloths wet with copper sulphate (blue vitriol) or water or immerse in water. Pick or squeeze out particles. Treat for burn.	10 minutes.	Burns out.
INCENDIARIES	THERMIT $8Al + 3FeO_4$	INCENDIARY	None	5,000 degree heat ignites materials.		None needed.	Treat for severe burn.	5 minutes.	Quickly cover with earth or sand.

GENERAL INSTRUCTIONS

The importance of proper first aid for gas victims cannot be overemphasized. The following are general rules which apply in all cases.

A. Act promptly and quietly; be calm.

B. Put a gas mask on the patient if gas is still present or, if he has a mask on, check to see that his is properly adjusted. If a mask is not available, wet a handkerchief or other cloth and have him breathe through it.

C. Keep the patient at absolute rest; loosen clothing to facilitate breathing.

D. Remove the patient to a gas-free place as soon as possible.

E. Summon medical aid promptly; if possible, send the victim to a hospital.

F. Do not permit the patient to smoke, as this causes coughing and, hence, exertion.

KEY

HOSPITAL CASE

FIRST AID TREATMENT

SMOKE

INCENDIARY

MASK PROTECTION NEEDED

FULL PROTECTIVE CLOTHING NEEDED

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have to take different protective measures against one agent than against another. You ought to be able to recognize quickly what kind of material it is, and know what protective measures to take. It is easier to protect against nonpersistent agents than against persistent agents.

Gas masks will protect against certain things, but not others. So you need to be able to identify. The best way of identifying chemical agents probably is by the odor. Everywhere a man goes, he will always carry his nose. That is about the best detector. Everybody ought to be able to identify the more commonly used chemical agents.

We have two or three devices for training people to identify odors. This series of bottles along the table is one method. We want to use that for a few minutes now and then. The last thing in the afternoon we will go outside and show you another method, but I want you to begin to become acquainted with some of these odors before we go out there.

Some of the most common agents are listed on the chart with an odor given opposite each. We don't care whether you learn those odors or not unless they will be helpful to you. The only way we have of describing an odor is to say it smells like something else.

Mustard gas, for instance, is shown as smelling like garlic, or horseradish. It may not smell like garlic or horseradish, but it will have a definite odor that we want you to fix in your mind so that when you smell that odor, you will think of mustard gas. To some people it smells more like onions; to others, like a skunk; and some say it smells like real mustard. It got its name because the British who smelled the gas thought it smelled like ordinary

mustard, and called it that. But the material isn't made of mustard at all. Nearly everybody who smells lewisite says it is similar to geraniums. Phosgene smells like cut corn, or like ensilage. If any of you have lived on a farm, you know what ensilage smells like. Chlorpicrin smells like flypaper. The point of all this is we want you to learn the odor so you can identify each agent without any question about it.

Some of the tear gases have a light odor like ripe fruit or apple blossoms. Some men can't smell it at all, but they can tell it when it hits their eyes. All these smokes have more or less of a smoky odor.

For the remainder of the period I want you to take turns in smelling these bottles, and comparing the odors with those of the chart. If you don't want to pay any attention to the chart, don't.

These agents are real, though they are mixed with some charcoal. Don't get them on your hands or clothes.

Handle these bottles very carefully. Just sniff the stopper. Don't put your nose down on the bottle. Don't smell too much. Your nerves are up in your nose, not down in your lungs. Don't breathe too deeply because you will deaden your own sense of smell. Smell only half of those bottles, and then at the close of next period before we go out of doors, come here and smell the other half. Don't get all your odors confused.

PERSISTENT AND NONPERSISTENT GASES

(Talk illustrated by chart showing gases and their physiological effects)

I shall take some of the samples of persistent and nonpersistent gases and talk about them.

Chlorine.

The first sample is chlorine as a common material. It is a yellowish-green gas which can be compressed to liquid form. Cl is the symbol for chlorine. It is also the chemist's symbol. Most of the symbols we use are not the chemist's symbols. This material is interesting in the study of chemical warfare because it is the first gas that was used on a large scale. We don't think it is so important now because protection against it is fairly easy. It killed thousands of men because they had no masks, no protection whatsoever. A few men saved themselves by breathing through a bottle of dirt or some similar device. Any good military mask today will give 100-percent protection against chlorine. For that reason we doubt whether it will ever again be used by itself.

Chlorine may be mixed with other agents since it is quite soluble in water. If you firemen were going against chlorine escaping from tanks or railroad cars, or industrial tanks which might have sprung a leak, a good fog nozzle would be a big help. A fog nozzle will dissolve a lot of that chlorine. It will wash it out of the air. You ought to follow use of the fog nozzle with a good flushing of water because chlorine solution is corrosive. An acid

is formed when the chlorine dissolves in water, and it goes to work on metals, and anything with which it comes into contact.

First aid for chlorine casualties includes removing the individual to fresh air or putting on his gas mask, keeping him quiet and warm, and followed by the treatment for bronchial pneumonia. A person exposed to chlorine has a choking sensation in his throat. His throat tries to close up because that is nature's way of keeping the chlorine out; as soon as it gets into the nostrils, into the mouth or throat, nature closes it off, and in doing so it shuts out the air as well. To prevent a man from choking to death, get him out into the fresh air and he will recover without any bad effects at all.

Another use for chlorine is in connection with decontamination. It seems queer that chlorine, a poisonous material itself, is used to decontaminate other poisonous materials, but that is a peculiarity of some of these agents. Mustard gas contains some chlorine, but if you put more chlorine in it, it becomes nontoxic. That is what you do when you decontaminate mustard gas; you put all the chlorine you can in the mustard gas. Chlorine is contained in most of our chemical agents. Only a few do not contain chlorine—incendiaries, magnesium, thermite, and combustible oils do not, but in general all the rest of them do.

Phosgene.

Phosgene belongs to the same group of lung irritants as chlorine, but it is a more deadly war gas than chlorine. It is a colorless gas, approximately 3½ times heavier than air when it is compressed to liquid form. It is a

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liquid of a light green color—lighter in color than chlorine, but similar in appearance. Phosgene is a little bit more persistent than chlorine, but still is classed as nonpersistent. Phosgene will last just about 10 minutes, and chlorine about 5 minutes. Phosgene has a stifling odor which to some people resembles new-mown hay. This agent chemically is relatively stable. It doesn't readily attack iron if the iron is dry, but if there is a little moisture, and phosgene becomes exposed to the moisture, acid will be formed, and there will be corrosion which will go to work on metal. You can readily store phosgene in iron or steel containers. It is one of the chemical agents that are readily destroyed by water. We don't ever use it while it is raining. Even if it were damp but not raining, and the other conditions were right, we wouldn't use it. Phosgene is a very toxic gas, being several times as toxic as chlorine. When inhaled, it acts with the fluid of the lung walls and blood to cause a break-down of the lung tissues. not even know it. He will feel good, he will play, and Frequently a victim will breathe more phosgene than he realizes because it produces few warning symptoms, and sometimes a man who has been gassed by phosgene may work, and eat a hearty meal, and live a normal life, then several hours, or even days later, he may die within a few minutes' time.

The proper first-aid treatment consists of keeping the patient quiet and warm, and in severe cases giving oxygen.

Ordinarily you won't come up against phosgene, but you might in an emergency. It is frequently generated by the decomposition of carbon tetrachloride when this material is used to extinguish very hot fires, especially metallic fires. Many cases have been known where civil-

ians were killed by phosgene gas generated when this material was used on a very hot fire. Phosgene is used in industry, and it might be stored.

Tear Gas.

The next gas is in the group called the lacrimators, that is, tear gas. Chloracetophenone differs, in several respects, from the agents previously described. It is a solid, remarkably resistant to heat and moisture. It is easy to handle and since it does not corrode metals it may be easily loaded into munitions, by casting, pressing, or pouring in the liquid form. It exists pure as colorless crystals which melt at 138° F. The very faint odor of chloracetophenone resembles the odor of apple blossoms. Our symbol for it is CN.

The most effective methods of dispersing this agent are from chemical grenades or candles, where it is distilled into the air by heat from some other burning substance or from shells or airplane spray tanks. From airplane spray tanks it is dispersed in the form of a solution, the CN being dissolved in some organic solvent such as chlorpicrin, chloroform, benzol, or carbon tetrachloride. The Chemical Warfare Service uses two solutions. The first, CNS, is a solution of CN in benzol and carbon tetrachloride. Lacrimators such as chloracetophenone have a great advantage because a very small quantity forces masking, with resulting loss of efficiency.

The physiological effects of this agent are temporary, though violent, irritation of the eyes resulting in copious flow of tears, and a burning sensation on moist parts of the body. It will cause a stinging sensation anywhere on

the body that there is perspiration. In cold weather you don't notice it, but in hot weather you notice it quite badly.

Nobody was actually ever killed with tear gas, and unless you get the solid into the eyes, there will be no permanent injury to the eyes. Do not rub your eyes if you are gassed with tear gas. Fan them, or if there is a wind blowing, face the wind and bring your eyes up to the wind. The wind will soon clear them and you will go about your business feeling pert and pretty good.

Tear gas finds its best application as a training gas, or for suppressing any form of civil disturbance. When the army, or national guard, or police are called out on riots or civil disturbances, CN grenades may be used. The CN would be present in solid form mixed with smokeless powder; it would burn the smokeless powder and drive off as a vapor, and that is the form in which you would encounter it in that case. When disseminated that way, CN would stay around for only about 10 minutes or less, and that is why I say it may be persistent. If you take the solid CN and throw it on the ground, it will be very persistent. It may stay there for days. If you burn it, and heat it, and drive it off as a vapor, then it won't stick around very long.

Chlorpicrin.

Chlorpicrin is not an important agent by itself, but it is used in mixtures with other agents. The important thing about chlorpicrin is that it will cause vomiting. Its symbol, PS, stands for Port Sunlight, the place in England where the men worked in connection with that stuff during the last war.

Adamsite.

The next material I want to talk about is adamsite, the irritant smoke. Its symbol is DM. It is a very stable compound, unaffected by water and quite insoluble in most solvents. From burning type munitions it distills into the air as very minute solid particles. The only particles that we know of that are smaller are cigarette smoke particles. When used as a smoke, its particles are so fine that a gas mask must contain a very efficient mechanical smoke-filter to afford protection. DM is often mixed with CN and used very effectively in suppressing mob disorders. It is the only agent we have that gives a yellow cloud, and that is the way you would have to identify it, because there is no odor.

Its physiological effects are severe irritation of the mucous membranes of the nose and throat, violent sneezing and coughing, severe headaches, acute pains and tightness in the chest, and finally nausea and vomiting. However, no serious permanent after-effects result.

An officer was gassed not very long ago in some of his work with DM, and he was laid up for about a day because every tooth in his head started aching. Some men have described the effect of that material as being seasick, and of having a cork in your throat so you can't do anything about it because it has a tendency to sort of paralyze the muscles. Sometimes you vomit, and sometimes you wish you could. It makes a person feel as if he were going to die, and he is afraid that he won't be able to. The remarkable thing is that while DM has such a violent effect almost immediately, no ill effects persist. A man may be knocked out from 12 to 72 hours, then he is ready to go

about his business, never knowing anything happened to him after that time.

Vesicants.

We consider the vesicants the most important of the chemical agents. Mustard gas is sometimes described as the "king" of war gases. Mustard came on the scene of action rather late in the last war, yet it produced a larger number of casualties than any of the other agents. A smaller percentage of those casualties died, but the gas knocked a lot of people out of combat for a very great length of time. Mustard gas is used to produce casualties or to run somebody out of an area through the threat of casualties. Its symbol is HS.

Mustard is classified as a persistent casualty agent of the vesicant class. Mustard is not a real gas but, at ordinary temperatures, a transparent oil liquid, one-fourth heavier than water. It freezes at 46° to 50° F. The vapor is approximately 5½ times as heavy as air and is almost odorless in light field concentrations. In stronger concentrations the odor resembles horseradish, garlic, or onions.

Mustard is one of the most persistent agents. The persistency varies from 1 day in the open and 1 week in the woods in summer to several weeks both in the open and in the woods in the winter. Mustard is primarily a vesicant, or blistering, agent, but its vapor is also highly toxic when inhaled. Food or water contaminated with mustard also has a toxic effect if taken into the body. The first symptoms of HS poisoning appear in from 4 to 6 hours after exposure but 24 hours may elapse before the complete effect is noted, the time varying greatly with the concen-

tration to which the victim is exposed. Sensitivity varies greatly with individuals but no person is so resistant to its action that he will not become a casualty if exposed for any appreciable length of time.

The first effects of HS which may be noted are inflammation of the eyes, followed by an itching and blistering and ulceration of the skin. While the ulcers are not very painful, they are slow to heal and easily become infected. The gas mask affords adequate protection against breathing the vapors of mustard gas, but a man must be furnished special clothing and shoes for protection from liquid mustard, or vapors.

The next vesicant gas I will discuss is lewisite, or M–1. Lewisite, like mustard, is a liquid. Its freezing point is 0° F. It is a persistent vesicant but has the added effect of causing systemic arsenic poisoning. M–1 has a faint odor which resembles geraniums. Smelling it causes a very disagreeable burning sensation in the nose and throat and sometimes violent sneezing. It is readily soluble in absolute alcohol, benzine, kerosene, olive oil, and a number of other solvents. It differs from mustard in that the physiological effects usually appear in about 1 hour and are more painful than mustard. Water readily hydrolyzes lewisite but the hydrolysis product, M–1 oxide, is very toxic. The protection necessary against lewisite is the same as for mustard.

Lewisite has never been used in a war. It was made during the last war, and was on its way over, but the armistice was declared, and we have never seen it act under actual warfare conditions. I am more afraid of lewisite than I am of mustard gas, regardless of what anybody else may think.

PROTECTION AGAINST WAR GAS

You gentlemen have been told about the properties and effects of the chemical warfare agents. Now the question is how to protect against them.

Methods of Distributing Chemical Agents.

Chemical troops use three principal types of matériel for dispersing chemical agents. These include the portable cylinder, the livens projector, and the 4.2-inch chemical mortar. The cylinder is a portable device in which the chemical agents are carried to the front-line positions on the backs of individuals. Each cylinder is equipped with a valve which is opened on the proper signal and the gas from thousands of these cylinders escapes and moves downwind in a cloud formation.

The livens projector is a short-tube wide-bore mortar with a rather short range. These tubes are partially buried in the surface of the earth at an angle of 45° and great numbers of them are fired simultaneously by electrical means. The livens projector is used primarily to place extremely heavy concentrations of nonpersistent agents on the enemy. Success in using a nonpersistent agent such as phosgene (CG) depends upon placing the gas on the enemy in the shortest possible time. This was done during the World War by the British when as many as 6,000 livens were fired at one time.

The 4.2-inch chemical mortar derives its name from the fact that its bore is 4.2 inches in diameter. It fires a shell weighing about 25 pounds of which the chemical filling weighs about 8 pounds.

The various types of filling used are white phosphorus, mustard, and lewisite. The artillery also disperses large quantities of chemical agents in all size weapons, 75 mm., 105 mm., and 155 mm. During the World War the chemical shell for the artillery became so important that if the war had continued, plans had been made to fire 75 percent of all artillery shell with a chemical filling.

For our consideration in this class, the most important and most dangerous method of dispersal is by airplane. Great strides have been made in methods of transporting and releasing chemical agents from airplanes. Your work as firemen in our large cities, all of which are subject to attack in case of war, will be complicated tremendously in case mustard gas is sprayed from airplanes.

Meaning of "Protection."

What does the term "protection" mean? In Chemical Warfare Service language, we mean to shield or secure the military forces against actual or prospective danger. Protection is really a passive subject. A city is *defended* by its armies, but protection is afforded the individual in the city by use of gas masks, protective clothing, and various collective protection devices.

Protection is a vital factor in war. The individual desires protection because of the fundamental instinct of self-preservation. He clings to life, and seeks both instinctively and deliberately to protect himself. A military fighting unit, however, must have protection even if the human urge of self-preservation were entirely lacking.

To accomplish its mission, an army must protect itself and avoid an excessive loss in casualties. Hence, there

is both an individual and a military demand for protection in war regardless of what weapons or means are used.

Who Is Responsible for Protection?

In the military establishment, the commanding officer is responsible for protection. In civil defense, the organization for training and protecting the general public against an air attack may fall upon the fire department and police department of our cities. You gentlemen will undoubtedly play some part in the training of the civilian population against gas and incendiary attack from the air.

The Army has various units such as the Chemical Company, the Depot Company, Maintenance Company, Decontaminating Company, and field laboratories within its organization. These groups are equipped and trained to deal with chemical agents, to decontaminate areas where necessary, and even to collect and analyze enemy agents in unexploded shells or bombs.

Highly trained specialists known as chemical officers are found in the headquarters of armies, corps, and divisions. These officers are from the Chemical Warfare Service branch and act as advisors to their commanding officers in all matters pertaining to chemical warfare. In smaller units, certain noncommissioned officers are trained in chemical warfare schools to act as regimental, battalion, and company gas officers.

I foresee a growing need for a civilian defense organization in our large cities which will subdivide down to the point where one individual will be responsible for the training in defense against chemical attack of not more

than 200 students. Such an organization will require time and planning to put it in working order. You gentlemen are here to gather useful information against the day when you will be called on to fit into that picture somewhere.

Individual and Collective Protection.

There are two general types of protection which we will discuss in this course. The first is individual protection and deals with the equipment required to protect a person against chemical attack in the open. Collective protection deals with the construction of gasproof buildings designed to shelter a number of persons.

At present, the British are protecting themselves in the subways and other bombproof constructions. Provided that gas is not used, such construction is adequate, but the use of chemical agents will necessitate a much different type of collective protection. Details of that construction will be described later.

You will be given an opportunity to examine a permanent collective protector developed by the Chemical Warfare Service. You will also visit the gas mask factory so that you may see how carefully masks are constructed and at what speed the work is carried out. You will benefit from knowing that masks are being made in great numbers and that steps are being taken for the protection of the American Army and the American population.

There is a principle which might appeal to you as firemen. We can see that protection bears the same relationship to first aid as fire prevention does to fire fighting. You are all convinced of the importance of fire prevention

work. It will therefore seem sensible to you that considerable time should be spent in developing protective measures against chemical attack so that less effort will be required in first-aid measures when the attack comes. You try to prevent as many fires as possible, but, if one comes, you do your utmost to minimize its effects. We will all train ourselves, civilian and military personnel alike, in the use of protective measures. If the gas attack comes we will expect the minimum need of first aid if our protective training has been adequate.

Gas Warfare.

Gas is an insidious thing. It creeps up without warning; it shoots around corners and penetrates even the lowest dugout unless particular care has been taken to protect against it. Gas warfare is hard on the morale of every one concerned. Napoleon said, "In war, the morale is to the physical as three to one." In a war in which chemical agents are used, the morale factor is even greater. If a man is assured reasonable protection against gas, he will be far more valuable than if his innate fear of this subtle weapon was allowed full sway. The gas mask and other forms of protection have been developed to such a high state of perfection that no one need allow a fear of gas to get the best of him. Careful training of the population in use of the gas mask and in gas discipline will cut down gas casualties to a minimum.

Warfare from the beginning of time has been a struggle between methods of offense and defense. During the Stone Age man developed crude weapons to be used directly against the individual. Man developed collective means of

protection by fortifying the entrance to his cave or building stockades. Later the bow and arrow, spears, and other missiles to be used at a distance required even better means of defense and the establishment of outposts. The invention of gunpowder and the rapid development of all forms of firearms only increased the need of defensive works. War, therefore, from the Middle Ages until the World War was a matter of use of stone or steel missiles projected by various means. On the Western Front in 1914 a stalemate was quickly reached. Trench warfare made it impossible for direct firing of weapons to overpower the enemy. The adoption of chemicals as a weapon was as logical as it was inevitable in a war in which all the combatants were highly developed in science.

The new weapon proved its value immediately. The first gas attack was made on April 22, 1915. There was no such thing as a military gas mask and a cloud of chlorine gas was floated from the German front lines pouring into the trenches as it moved. The French-African troops fled in complete abandon. Their retirement was instinctive and probably justified. The gas attack was not completely unexpected. The English had word through their intelligence sections that the Germans were planning on using gas, but unfortunately they gave it no serious consideration.

From that moment, means of protection against chemicals were quickly devised by the British. The first protective device consisted of a black veiling dipped in a solution of hypo. Pails of this solution were kept in a handy place in the trenches and upon the sounding of a gas alarm the men grabbed a piece of waste, or cloth, dipped it in the solution, and then tied it over their mouth

and nose. This crude device was partially successful against short attacks of chlorine gas, but subsequent concentrations caused many casualties. It was evident that a better mask was needed.

I need not go into detail on the development of the gas mask. You have visited the museum where you saw the various steps in the development leading up to the present efficient service mask used by the United States Army. During your course you will be issued a service mask, taught the correct use of it, and methods for repair of the mask.

You might be interested in a few figures concerning gas casualties during the World War. Chemical agents caused more casualties among the A. E. F. than any other single class of weapon. Despite the staggering total of gas casualties, the deaths attributable to chemical agents were few. Of all the battle casualties in the A. E. F. obtained from every source—machine guns, high explosive, rifle, bayonet, and gas—27 percent were caused by gas. However, out of this 27 percent, only two percent died, in contrast to 25 percent who died of the total casualties from all other sources.

When one considers the figures which show that four men are required to take care of one wounded or sick man during a war, we can understand why it is more desirable to wound the enemy than it is to kill him. We can also understand from the percentages given above why we are so interested in and spend so much of your time in teaching protection against chemical agents.

THE SERVICE MASK

The gas mask is a basic item of individual protection. There is no substitute for it and no one should be without it when in danger of attack by chemical agents.

The principal of its action is that air breathed through a chemical filter where the poisonous gases are removed, permitting only pure air to reach the person wearing the mask. The mask does not manufacture oxygen. Its only function is to remove those gases mixed with the air that would cause death if breathed.

The gas mask was first patented in this country in 1874, but not until the World War was the development of the gas mask taken seriously. The history of its development is too long a story for this short course. We will consider your trip to the museum as being a satisfactory introduction to the study of the present service mask.

The service mask is a result of laboratory development, as well as field tests. Continued change and improvement have given us a very efficient and reasonably comfortable mask. It is carried in a satchel carrier which reduces to a minimum inconvenience to the user.

Requirements of Mask.

The requirements of a good gas mask include the following: (1) It must protect against all gases used in the field, that is, all gases used in chemical warfare; (2) it must be simple in design, easy to put on and repair; (3) it must be comfortable to wear, light in weight, and have low breathing resistance; (4) it must permit relatively unimpaired vision; (5) it must be rugged enough to stand

up under field use and have a service life in the field of at least several months; (6) it must be reasonably easy to manufacture in quantity and be suited to storage.

Any mask having all of these advantages would be ideal. The ideal mask should protect against all poisonous gases but such a mask has been impossible to develop to date.

Masks for Firemen.

We must not depend on the military mask for all occasions. *It is not designed for fire fighting.* Firemen have their own type masks produced commercially which when worn permit them to enter an atmosphere of carbon monoxide, and also masks which may be used in ammonia and hydrocyanic acid gas. The military gas mask does not protect against these gases. A good general rule is never enter an area containing an unknown gas with any type of mask in which the air must be breathed through a chemical filter. Rather, it is advisable to use an oxygen mask or one in which air is forced in from the outside.

Types of Masks.

The various types of gas masks include the following: Service mask, training mask, noncombatant mask, optical, diaphragm, special-sized masks for children and babies, horse masks, dog masks, and pigeon bags. Samples are here for you to examine.

The Chemical Warfare Service has been trying to construct a mask for particular duties. Aviators require specially constructed masks, as do Navy personnel, firemen, persons using instruments, and those giving commands.

The Army service mask, complete, has three main parts: The facepiece and hose, the canister, and the carrier.

The Facepiece and Hose.

The facepiece is constructed of molded rubber or stockinet-covered rubber sewed into shape. Eyepieces are fitted into this facepiece and a head harness sewed or riveted to it. An angle tube is attached to the bottom of the facepiece. This permits the fresh air coming through the hose to enter the mask. The cool incoming air is forced over the eyepieces by a part called the deflector. By passing the cool air over the eyepieces, we minimize fogging due to the moisture. The angle tube also contains an exit for exhaled air. An outlet valve, protected by a guard, is fastened to the angle tube and only allows exhaled air to pass out of the facepiece.

The Canister.

Purified air reaches the facepiece through the canister filled with a quantity of chemicals—mixture of activated charcoal 80 percent and soda lime 20 percent. The incoming air must pass through these chemicals before entering the hose. Activated charcoal has a tremendous affinity for chemical warfare gases and imprisons them on its surface until they can be destroyed by the soda lime.

To protect against minute particles of toxic smokes the mask is equipped with a mechanical filter composed of finely packed threads of cellulose fibers or other porous material such as filter paper. You will notice that there are two filters in the mask, the mechanical filter for solid

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particles, and the chemical filter for gaseous particles. A one-way valve in the bottom of the canister permits air to enter.

The Carrier.

The carrier is of cloth, designed to hold the canister at all times, and the facepiece and hose-tube when they are not in use. The carrier is designed so that the tube and facepiece are held without undue bending or crowding. It is essential that the mask be placed in the carrier in the proper manner after using so that there is no unnecessary crowding or kinking of the rubber parts.

Sizes of Masks.

The service mask is now made in a universal size designed to fit over 95 percent of all faces. It might be considered as a funnel-shaped object into which the small face enters further than the large face, but designed so that in all cases a gas-tight fit is obtained at the edge. For the unusual size face, either extremely small or large, the Chemical Warfare Service manufactures special-sized masks—No. 1 for the small face and No. 5 for the large face. In case the universal mask does not give a good fit, the individual should be provided with one of these special sizes.

Contents of Canister.

Activated charcoal was first made from fruit stones, nut shells, and other forms of dense wood. During the world war charcoal was imported because we felt that our charcoal was inferior. Tests showed, however, that charcoal

made in the United States from ordinary woods could be heated and steam treated in certain ways which would give an activated charcoal much superior to anything imported. We can now make all the charcoal that can possibly be required right here in this country.

Soda lime is easily prepared and reacts chemically to destroy various gases. The contents of a mask canister are affected by moisture, making the chemical mixture solidify into a mass which hinders the passage of air and decreases the chemical efficiency. Care must be taken to prevent water entering the canister, but, if it does, the canister should be replaced.

Remember that the service mask canister does not supply the oxygen. It only removes certain gases. Even war gases in concentrations greater than 1 percent may find their way through the canister. If an individual finds himself in an extremely heavy concentration of gas, he should hold his breath and move out of the area. Otherwise, he may become a casualty.

Life of Canister.

The service canister has an active lifc of about 40 hours, while the training canister and noncombatant canister is good for only 13 hours. Fortunately a canister never gives out completely and suddenly. The individual wearing the mask will be warned of its decreasing efficiency by a slight leakage of gas. This indicates the need of an immediate change of canisters. A brief record of the time spent in gas while using a particular canister would be advisable. Such a record would warn the individual in ample time to replace his canister after having used it for the 40 hour period.

Special Canisters.

Special canisters are manufactured by the Chemical Warfare Service. A canister painted white so that it may be distinguished easily is designed to protect against gases used for fumigation purposes. A green canister is designed to protect against ammonia. A black canister protects against oil fumes. Still others are designed to protect against acid fumes and alkali. You firemen are familiar with the all-purpose canister and the oxygen mask.

Horse Masks.

Finally, the Chemical Warfare Service has developed masks to protect horses against chemical agents. Blister agents such as mustard and lewisite will burn a horse almost as quickly as a human. Phosgene and the other lung irritants will quickly disable the horse as they do a man. It is therefore necessary that some protection be provided for animals. Dogs are also susceptible to chemical warfare agents and a mask has been designed for them. Carrier pigeons are transported in cages protected against chemicals by special covers.

IIIG

NONCOMBATANT MASKS

Noncombatant masks are similar in principle to the Army training mask. They are inexpensive but well made with respirator designed to protect the face, eyes, lungs, and throat. The noncombatant gas mask is suitable for protection of those persons who do not have to fight or work in the presence of gas.

The noncombatant gas mask will not protect the wearer from automobile exhaust fumes, from fumes arising in the fumigation of homes, nor from smoke or fumes from burning buildings. It must not be used where there is an insufficient supply of oxygen.

The student will consult the Instruction Pamphlet for a description of the noncombatant gas mask. This pamphlet shows by diagram how to put on the mask and adjust it to the face. These drawings of faulty and correct adjustment will readily teach the individual how to use this type of mask.

The noncombatant mask is furnished in three sizes: large adult, small adult, and child. The facepiece is of special impervious fabric. Eyepieces are of transparent sheet plastic material and are sewed into and cemented between layers of fabric. The canister is attached directly to the front of the facepiece and gives the same protection as provided in United States Army training masks. This protection is equal to and in some cases superior to that furnished by the best gas mask used in World War No. 1.

All persons, particularly civilians, should remember the following rules for care of noncombatant respirators:

1. Put on and take off carefully so as not to damage.
2. Test valves periodically.
3. Keep in cool dry place.
4. Dry inside after using—moisture causes deterioration.
5. Don't distort or carry by straps.
6. Keep in carrier provided.
7. Avoid damage to eyepieces; they are sewed in.
8. Don't crease, scratch, or dent eyepieces.
9. Take care of mask and carton.
10. Treat outlet valve carefully.

CARE, STORAGE, AND DISINFECTION OF GAS MASKS

Everyone concerned with the use of gas masks must realize that this type of equipment demands certain care if it is to give satisfactory service. Many things will cause deterioration. Moisture, for instance, will clog up the canister, destroy the chemicals, and increase the breathing resistance. Moisture also affects the tape on the chin seam and the tape which covers the wire binding allowing them to rust and weaken. Age will cause rubber to lose its resilience and elasticity.

Storage of a gas mask with the hose improperly placed in the carrier will result in a permanent set in the tube, which makes replacement necessary. When masks are stored at the factory they are often stored in an atmosphere of inert gas, such as nitrogen. At Edgewood Arsenal the masks are now being packed in airtight cellophane bags. These bags slow down the natural deterioration due to the action of oxygen of the air with the rubber.

After masks have been issued to individuals, they should be stored in storage racks. Masks should always be kept away from sunlight, oils, and corrosive liquids or solids. They should be stored in a cool place if possible. Separate canisters should be kept as dry as possible. A cork placed in the angle nozzle tube will help to keep moisture from the canister contents.

Canisters are designed to give service for a long period if carefully handled. The field life will depend upon the amount of gas in the air and the length of time the in-

dividual wears the mask. Where the wearer is subjected to heavy concentrations over long periods of time, replacement will be required much earlier than where the gas concentration is lighter. To be on the safe side, canisters should be replaced too soon rather than too late.

Adjustment and Repair.

Gas masks may fail to protect for one or more of the following reasons: (1) A poor fit. (2) An improper adjustment of the head harness. (The head harness need not be extremely tight; just tight enough to give an airtight fit and no more.) (3) The leakage of a valve or facepiece defect, such as a hole.

The fit of the mask is dependent on the judgment of the individual using the mask. The adjustment of head harness is also an easy matter to take care of. Holes in any part of the mask or improperly fashioned valves are matters for repair.

Repair kits are supplied to all Army organizations and no doubt will be supplied to civilian organizations such as fire departments and police departments for use in repair of civilian masks. Members of civilian defense classes will have an opportunity to repair a gas mask—replace defective parts, apply patches to holes in rubber parts, and repair or replace head harness.

Disinfection.

In disinfecting the gas mask it will be necessary to use two disinfectant agents, formaldehyde and creosote. Formaldehyde 3 percent solution is used to disinfect all masks having cellulose acetate eyepieces. For masks having glass

lenses we may use creosote or lysol solution with a strength of 2 percent. The inside of the mask is wiped out with a cloth dampened with the disinfecting solution.

Be sure to hold the mask in such a manner that the solution does not run down the hose tube. Wipe off any excess liquid but leave the parts moist. A drop or two of disinfecting solution should be placed in the outlet valve very carefully, and allowed to remain there. The mask is then hung up to dry and then is placed in the carrier.

GAS MASK DRILL

During your course at the Chemical Warfare School you will be given a number of opportunities to take part in and to conduct a gas mask drill. Even civilians should become familiar with the steps involved in the drill so that they may develop the proper habits in use of this phase of individual protection. Constant practice, according to the fixed drill routine, will instill the procedure into each individual so firmly that during the strain of an emergency those necessary steps will be followed as a matter of habit.

Steps in the Drill.

Preliminary drills will be given by numbers in order to acquire completeness and accuracy in adjustment of the mask. This will habituate the individual in its correct manipulation. Proficiency in this drill will be followed by training without the numbers to insure rapidity of adjustment.

1. To sling the mask. In this drill we learn to place the mask in its carrier on the person. With the carrier held in the left hand, flap of carrier facing away from the body, the command is: 1. SLING, 2. MASK. With both hands grasp top of shoulder strap. Swing strap over the head and at the same time pass the left elbow through the loop. Place strap at junction of neck and right shoulder. Straighten out strap and fasten the hook. Place the body strap in position and fasten. The length of straps should be so adjusted that the mask hangs comfortably

under the left arm, not too tight under the armpit, and about waist high. A waist strap should be tight enough to keep the mask firmly against the side.

2. To adjust the mask. 1. The carrier being slung, the command is: GAS. At the command GAS, remove and dispose of head covering with the left hand and at the same time open the flap of the carrier. Remove the mask by grasping top of facepiece with the right hand. Bring the facepiece forward in front of the face smartly. Place thumbs under lower head-harness straps and inside facepiece, while fingers support facepiece outside. Raise the mask to a level with the chin and thrust the chin forward. 2. Seat the chin firmly in the mask and place the facepiece and head harness with an upward and backward sweep of the hands. Adjust the head-harness pad and smooth out edges of the facepiece. 3. Close the outlet valve by pinching between the fingers and breathe out sharply and suddenly. This will clear the facepiece of any gas which might have been present. Recheck the fit of the facepiece. 4. Replace the head covering; fasten the carrier flap. This completes the exercise. NOTE.—During this complete exercise, from the minute that the cry of Gas is made, the individual should hold his breath. We assume that when the cry of GAS is made that the individual will put on his mask and save whatever air is in the lungs to clear the facepiece as in step number 3 above.

3. To check fit of mask. The mask being adjusted, the command is: 1. CHECK, 2. MASK. At the command MASK, with the thumb and forefinger, pinch the walls of the hose-tube close to the canister. Inhale. The facepiece should collapse against the face and no air should enter

around the facepiece. In fact, the individual should be immediately aware that no air is entering the apparatus at any point.

4. To test for gas. The mask being adjusted and the fit having been checked, the command is given: TEST FOR GAS. Take a moderately full breath and stop breathing. Stoop close to the ground but without touching any part of the person or equipment, to the ground, other than the feet. Insert two fingers between the face and facepiece so as to permit air to enter at that point. Sniff gently but do not inhale deeply. Resume the erect position. Clear and reseat the mask as prescribed in step Number 3 of the adjustment drill above. Resume normal breathing.

5. To remove the mask. With the mask adjusted, the command is: 1. REMOVE, 2 MASK. At the command MASK, test for gas and clear facepiece. If no gas is detected, proceed with removing the mask. Open the carrier using both hands. Remove and dispose of headpiece. With both hands grasp the lower edge of facepiece on either side of chin by inserting thumbs between facepiece and face. Using a downward, outward, and upward circular motion remove the mask from the head, using care in slipping lower head-harness straps over the ears, and retaining firm hold on mask.

6. To replace the mask. After removing mask, the command is: 1. REPLACE, 2. MASK. With the right hand grasp facepiece, place head-harness inside facepiece, and bring hose up and inside facepiece. Hold carrier with left hand and replace mask in carrier, eyepieces to the front. Work mask into carrier gently without forcing. If the

hose has been handled correctly, it will be found to lie in the curved bottom of the carrier. Refasten carrier.

Visual Inspection.

The inspection procedure for the mask is as follows: Remove mask and canister from carrier. Inspect parts in this order: canister, hose-tubes, outlet valve and guard, angle-tube, facepiece, and head-harness. Place and hold mask under right arm. Inspect carrier and antidim set. Replace mask in carrier.

IIIJ

THE GAS CHAMBER FIELD EXERCISE

The purpose of this exercise is to test the fit of the gas mask, to give practice in adjustment under simulated field conditions, to promote confidence, and dispel the inherent fear of gas which everyone has.

We will use a peacetime gas chamber in the form of a tent. We will develop a strong concentration of tear gas (CN) by means of a small improvised stove on which we will place solid chloracetophenone. As students, you will first be drilled in inspection and testing of the gas mask, then you will enter the gas chamber with masks adjusted. Stay in the chamber 5 minutes and examine the improvised tin can stove used to generate the gas. Leave the shelter and stand inspection. Do not remove the mask until instructed to do so.

The instructor examines each man individually to see whether the mask is properly fitted. Tears will indicate that the fit was not good and that the individual has been gassed. Steps are taken to correct the deficiency.

The students next enter the shelter again and, one at time, they remove masks; after satisfying themselves that tear gas is actually present, they leave. An attendant is stationed at the door to assist those having trouble leaving the gas chamber because of inability to find the exit.

Each individual is cautioned to face into the wind after exposure to tear gas, and not to wipe the eyes.

This exercise will convince everyone that as long as the mask is in serviceable condition, and properly worn, he is being protected against chemical agents.

At this school the students may be allowed to enter a lethal concentration of chlorine, but all precautions must be taken to assure the proper fitting of the mask and an understanding of the hazard involved. All persons should be warned to remove jewelry of all kinds before entering an atmosphere of chlorine. This phase of the training might well be made a matter of choice for each individual. While in the chlorine chamber, the attendant allows some liquid chlorine to escape so that the student may have a better understanding of the physical properties of chemical agents when stored in confined spaces, such as cylinders or shell.

IIIK

PROTECTIVE CLOTHING

The gas mask protects only the respiratory organs. Modern chemical warfare finds great use for the blistering agents; namely, lewisite and mustard gas. Both of these agents, whether in the liquid or gaseous phase, will readily penetrate cloth or leather. Consequently, any person who is to be exposed to these vesicant gases must be protected by special protective clothing.

Types of Protective Clothing.

We classify protective clothing as being *impermeable* or *impregnated.*

Impermeable clothing has the following characteristics: It is usually a cloth coated with rubber or oil substance. It sheds vesicants (blistering agents) mechanically. It is uncomfortable to wear for long periods. Renovation or repair is impractical.

Impregnated clothing is treated cloth. The cloth is impregnated with certain chemicals which neutralize the effects of war gases. Such clothes are relatively comfortable to wear. Renovation is possible and the cloth can be sewed or repaired like any other cloth. The life of protective clothing depends on the concentration of the agent and the method of dispersal of the agent.

Impermeable Clothing.

Impermeable clothing is not designed to be worn for long periods. It is to be used during and after the attack and for decontamination operations. A man can wear this type

of clothing for periods of about half an hour to 1 hour. Warm weather adds to the discomfort of wearing impermeable clothing.

One of the best-known materials used for impermeable clothing is "alligator" cloth used for making raincoats, and so forth. A suit of this material, if made with gas-tight closures at the wrists, neck, and ankles, will protect the wearer against liquid or mustard gas. The garment should be designed with a hood which will fit tightly around the facepiece of the mask and completely cover the head and shoulders of the wearer. Rubber boots and rubber gloves complete the outfit. Firemen may find that the rubber clothing which they are now expected to wear will adapt itself to decontamination operations.

Impregnated Clothing.

It has been found advisable by the Army to equip an individual who is to undertake decontaminating operations with a full set of underclothing which has been impregnated. This is to protect against any possible leakage of vapors or liquid through the impervious outer garment. In case shoes are worn instead of rubber boots, they must also be impregnated and a wearer must occasionally shuffle his feet in a mixture of chloride of lime or sand and dirt.

Developments With Respect to Protective Clothing.

Attempts have been made to design a ventilated garment of the impervious type. Such a garment would be desirable but is costly to make, bulky, and not completely satisfactory. A certain amount of time is required to don

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these protective outfits. Hence we cannot expect everyone to be equipped to withstand a direct spread of mustard without casualty.

Capes of cellophane have been advised for use by civilians and others. These will cover the entire person, and due to the transparency, no opening is required for vision. Cellophane shows a remarkable resistance to the passage of mustard. Where cloth allows mustard to pass through in a few minutes, the time of penetration of all-cellophane is a matter of hours. These capes cost little and are to be disposed of by burning when once contaminated.

There are many commercial fabrics under investigation for use in making impervious clothing. Among these fabrics are thiokol, a form of rubber material; revolite, a modification of bakelite; and certain flexible glass fabrics. All of these substances have different wearing qualities and are resistant to mustard. All will be used in case of necessity and industrial concerns will be depended upon to furnish anything needed in this line. The Chemical Warfare School is not concerned in furnishing these garments to civilians but rather it is interested in teaching you how they are used and their limitations.

Leather.

Leather is easily penetrated by mustard. For that reason shoes must be impregnated so that any mustard will be neutralized when coming in contact with leather. Old leather is much easier to penetrate than new. There is no better treatment for shoes than by occasionally stepping into the box of bleach-dirt mixture mentioned above. Ordinary rubber clothes, if available, will give good pro-

tection but should be worn over impregnated clothes as a safety precaution. Occasional washing of rubber clothes in a decontaminating agent, noncorrosive, is a worth-while safety precaution.

Salve.

Protective salve has been devised by the Chemical Warfare Service which will mitigate the action of mustard particles on the skin. Some such material undoubtedly will be prepared by commercial firms for issue to civilian population if necessity demands.

Removal of Contaminated Clothing.

Great care must be taken in the removal of contaminated clothing. The services of an attendant are required and the individual must be unclothed without contaminating himself by the outer clothing. After removal of contaminated clothing the individual should bathe thoroughly with warm water and plenty of strong soap. Naturally, clean clothing must be issued after the bath so that contamination may not follow.

DECONTAMINATION

We will divide the discussion on this subject into three parts:

1. Meaning of the term "decontamination."
2. Basic principles involved.
3. Materials used and methods of application.

Meaning of Decontamination.

By "decontamination" we mean the cleanup of any object or space which has been contaminated by mustard or lewisite. Since the subject is very broad, we will instruct you only in the basic principles and then expect you to meet any particular emergency situation when it comes. I will use the term "demustardize" to mean the same as decontaminate, since mustard will be the most-used persistent agent and whatever is said about mustard applies equally well to lewisite.

Purpose of Decontamination.

The fundamental principles of decontamination is to destroy chemically the mustard or lewisite. This destruction is easily accomplished in the laboratory. The chemist has many substances which will react with mustard and completely neutralize its action, but many of these substances also destroy clothing or metals or other material on which the mustard has been sprayed. We try first therefore to protect all clothing, weapons, vehicles, and so forth, by keeping them out of contact with mustard. But after an object has become contaminated or after a certain

area has been sprayed with mustard we may find it necessary to clean up that material or area so that it again becomes usable.

Ideal Agent.

The ideal agent for decontaminating has not been found. The ideal agent must have the following properties: 1. It must be cheap and easy to prepare. 2. It must destroy mustard promptly. 3. It must be easily stored. 4. It must not destroy other materials. 5. It must be easy to transport and noninflammable.

Decontaminating Materials.

We will now discuss the two most important decontaminating materials and see how far they fulfill the properties of the ideal agent. The two most important decontaminating agents are (1) chloride of lime, otherwise known as calcium hypochlorite; and (2) decontaminating agent, noncorrosive, which contains a material developed by the Chemical Warfare Service, dissolved in actylene tetrachloride.

Various methods of decontamination can be used which do not require the use of chemicals and which are partially successful in dealing with persistent gases. For instance, a contaminated road might be covered with dirt and then wetted down with water. This temporary expedient might do very well if no other method were available. Water reacts slowly with mustard gas and over a period of time nature will completely destroy this chemical agent. That fact immediately reminds us that an easy way to deal with a large patch of mustard would be to mark it

with signs and thereby isolate it, letting nature do the work of decontamination. However, we are mainly interested in this course in a quick decontamination in limited areas which must be used by the civilian population as soon after the attack as possible.

Chloride of Lime.

Of the two agents mentioned, chloride of lime is by far the most important. This agent can be used in three different forms. The first form is a *dry mix of chloride of lime and dirt.* The Chemical Warfare School advises a mixture of 1 part chloride of lime to 2 parts of dirt by weight. This will amount roughly to a mixture of 2 shovels of chloride of lime to 3 shovels of dirt, due to the greater weight of dirt and sand. This material should be mixed and spread over the contaminated area so that 1 pound of chloride of lime is applied to every square yard of surface.

For instance, if a street 150 yards long by 10 yards wide is to be decontaminated, we first figure the area to be 150 times 10, or 1,500 square yards. This means that 1,500 pounds of chloride of lime must be mixed with 3,000 pounds of dirt, and the resulting 4,500 pounds of mixture is then spread over the entire area. Those figures show the enormous size of the job. It would seem impossible to decontaminate unlimited spaces which had been sprayed with mustard. It is better to decontaminate only those sections most necessary and isolate the rest. We might even evacuate people from large areas.

The chemical action of raw bleach or pure mustard liquid is so rapid that the material bursts into flame and

a large volume of poisonous gas is evolved. To cut down the speed of chemical reaction, we mix the bleach with dirt or water.

Another method of using chloride of lime is to *mix it with water*. This mixture is usually made up in the proportions of 1 part chloride of lime to 1 part water. This mixture is approximately 3 shovels chloride of lime to 2 gallons of water. This mixture is given the name "slurry" at the school and is somewhat like thick whitewash. This material must be applied so that each square yard of surface receives the benefit of 1 pound of chloride of lime. Rather than memorize quantities, the individual should mix chloride of lime and water to the consistency of thick whitewash and then apply plenty of this mixture to the area being decontaminated. A thicker mixture, more like a paste, can be made for special purposes by adding less water and more chloride of lime. The slurry has the advantage of being adapted to spray apparatus. The Chemical Warfare Service has devised a 3-gallon sprayer (hand pump), and a 300-gallon type sprayer equipped with engine-driven pump and stirring mechanism.

Firemen will be greatly interested in the decontamination of streets. The first step will probably be to flush the streets with water, thereby washing most of the mustard into the sewer system. Next it will be advisable to spread a quantity of slurry on the street and work it into the surface with brushes or brooms. After this mixture has remained on the street for 15 minutes or more, it can be flushed off thoroughly and the street used without danger.

Where a building has been contaminated with mustard it may be found advisable to spray the walls around the

area with slurry, using the mechanical spray device. In that case we allow the slurry to dry on the walls, thereby destroying any mustard which may be soaked into the wood, brick, or stone of the building.

Slurry and chloride of lime paste both have the odor of chlorine and are very caustic to the hands. All persons working with chloride of lime should wear rubber gloves and a gas mask. Chloride of lime quickly corrodes metals. For that reason it is not well adapted to decontamination of metal objects. In case it is necessary to use slurry on metal objects, it should be washed off after 15 minutes and the metal surfaces dried, polished, and reoiled.

Noncorrosive Decontaminating Agent.

Chemical research has provided us with a new decontaminating agent, noncorrosive. This development of the Chemical Warfare Service is not at present available to the public but you will be given instructions relative to the mixing of the substance. If an emergency arises, civilian defense agencies will probably be given use of some commercial variety of this decontaminating agent. The mixture is placed in a 3-gallon pressure tank where it can be used to spray contaminated surfaces or contaminated walls.

This solution can be applied to all metal surfaces where it quickly and completely destroys mustard and lewisite. This agent is rather costly compared to chloride of lime. One gallon of the mixture costs about $2.50 and will cover about 10 square yards of surface. This means a cost of about 25 cents per square yard, while the cost of chloride of lime at 1 pound per square yard is about 3 cents.

Although decontaminating agent, noncorrosive, is eight times as expensive as chloride of lime, it has many advantages to overbalance the extra cost. It can be used on all surfaces, metal or otherwise. It is very rapid in action and the treatment can be repeated if necessary. Hands can be washed in the solution. It has one disadvantage which should be mentioned. It contains acetylene tetrachloride, which is a good paint remover. One should expect that repainting will be called for regularly after demustardizing operations.

Finally it should be mentioned that decontamination of an individual may be necessary. Beyond treatment of his clothing, the decontaminating operations are really in the nature of first aid. You will receive brief instructions on first aid of gas casualties.

COLLECTIVE PROTECTION—GASPROOF SHELTERS

Collective shelters are gasproof or gastight buildings which will protect a number of individuals against war gases.

We think of the gas mask as a basic item of equipment for individual protection; similarly, the gasproof shelter is a basic requirement for the protection of groups. Collective protectors are not a substitute for individual protection but rather are designed to give a place for military personnel to work, eat, or rest during prolonged gas attacks.

Temporary Shelters.

During the World War, stabilized warfare resulted in dugouts designed to protect against rifle and artillery fire. When the first gas attacks took place, it became evident that some provision would have to be made to keep chemicals out of dugouts. Because war gasses are all heavier than air, they very quickly roll into trenches and all subterranean openings. Dugouts are therefore constructed with double gastight blanket doors designed to be rolled up when not in use and dropped into position when the gas alarm sounds.

We have here a model dugout showing the arrangement of the air lock and double doors at the entrance. Chloride of lime is used to decontaminate shoes of individuals before they enter the inside of the gasproof shelter.

No fires can be allowed to burn in these shelters because of the draft which would bring in poisonous gases.

Permanent Shelters.

In rear areas or where civilians may need protection, a more elaborate system of collective protection is needed. Where possible, a building can be selected with few openings and with heavy construction to withstand shock of explosives. Windows should be sealed shut and double doors provided.

A motor-driven pump should be installed in such a manner that incoming air is drawn through large-sized canisters of similar construction to those in the service mask. Purified air then enters the room and causes a slight pressure inside the room, thereby stopping any leakage of air from the outside toward the inside. Due to a slight inside pressure the tendency would be for air to leak out of the room. This incoming supply of fresh air will make the gasproof shelter much more useful and the capacity would be increased and the comfort of all concerned would be improved.

If a person is expected to work while confined in a gasproof shelter or collective protector, he should be supplied with at least 5 cubic feet of fresh air per minute. If no work is to be done and the person does not expect to exert himself, it is possible to live in a confined space with only 1 cubic foot of air per minute. It can be seen from these figures that the ordinary type of gasproof shelter or dugout would be very uncomfortable if occupied over a period of time longer than a half hour. Ordinary gas attacks

using nonpersistent agents are finished within 15 or 20 minutes, after which the gasproof dugout would be opened up and aired out.

The more permanent installations could be installed only after careful planning of the structure in which they are to be put. If a collective protector has a motor driven pump, consideration must be given to the possibility of power failure. Such a device is therefore limited to areas far behind the front lines.

Contaminated Clothing.

All shelters whether of the temporary or permanent nature should have a place for contaminated clothing. The entrance of one individual who has been badly contaminated will not only result in that individual becoming a casualty, but the gases from his clothing may cause trouble for the others in the shelter. Chloride of lime should be provided in shallow boxes containing a mixture of this chemical with dirt or sand placed at the entrance so that all persons entering the shelter may scuff their shoes in the mixture and thereby neutralize the chemicals on their shoes. Other outer clothing which may be contaminated should be removed before entering the shelter. Large protective shelters will have bathing facilities, extra supplies to take care of persons who may have been stripped before entering the shelter.

Gasproof Shelters in Large Cities.

Since gases have a tendency to remain close to the ground, what would be the best location for gasproof shelters in a large city?

Modern concrete and steel construction of buildings makes it rather difficult for bombing planes completely to wreck such structures. Therefore, several rooms near the inside of a building (not outside rooms) are made gas-tight and a forced ventilation of air is drawn from an inlet several floors higher. Such a device should prove safe from gas attack. Gasproof rooms in basements have the advantage of more safety from high explosives but less safety from the entrance of poisonous gases.

Many suggestions have been made by experts for gas-proof shelters for large groups of individuals. Sir Malcolm Campbell, the English racing driver, suggested concrete structures which would act as shelters and automobile parking spaces. These should be entered by ramps rather than stairs and would hold large numbers of persons. J. B. S. Haldane, an eminent British scientist and writer, suggests collective shelters in the form of shallow tunnels with gastight entrance. It would appear that governments throughout the world are considerably more expert in planned destruction than in construction planning for protection.

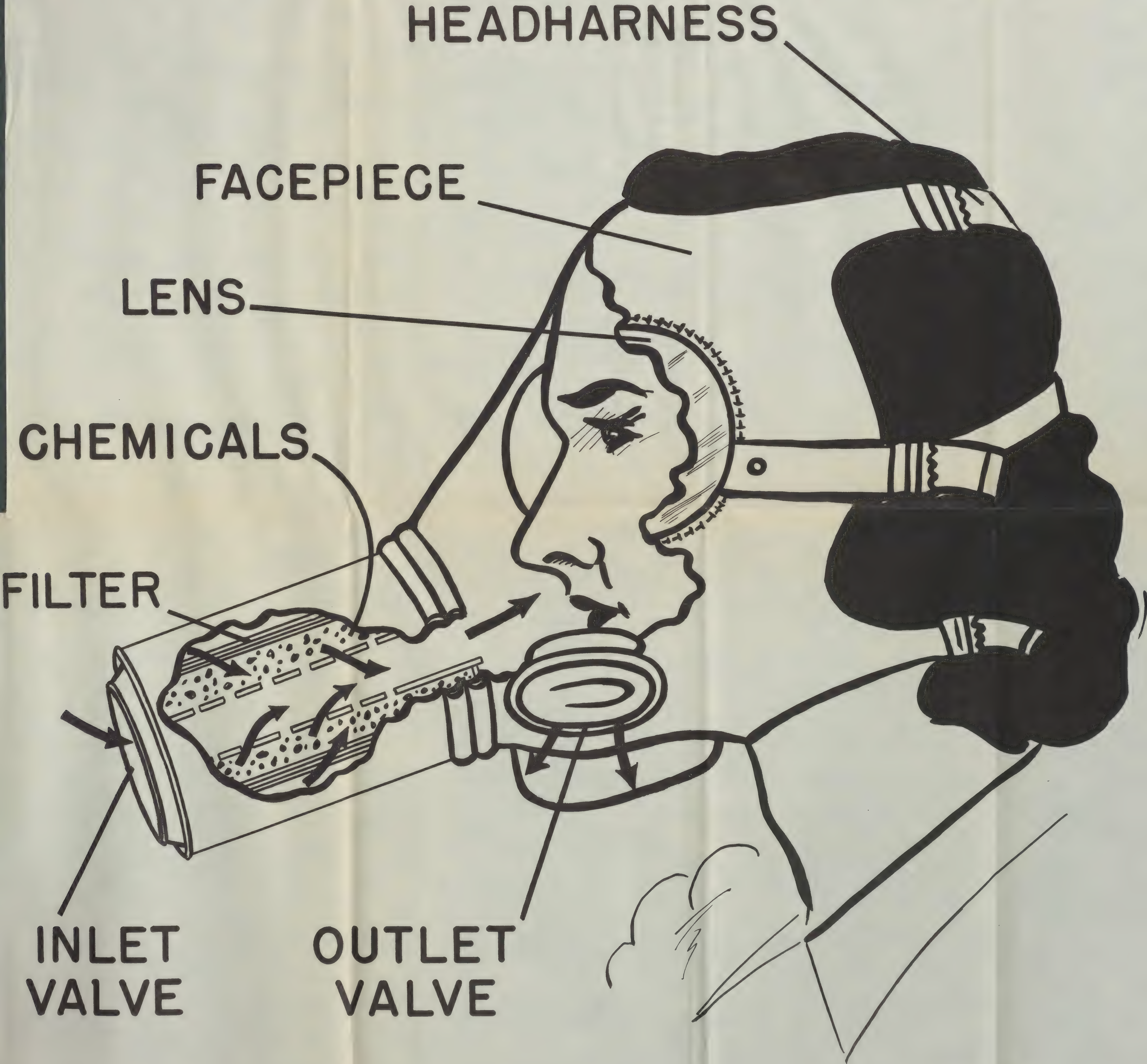
Colonel Prentiss, Chemical Warfare Service, wrote an article for *Popular Science* of May 1941, in which he discussed various types of gasproof shelters for the individual family. Among the types mentioned he discussed a refuge room constructed within the home. He suggested that the room be a corridor or inside room. The windows should be shielded from bomb blast by construction of brick walls outside of the windows or by piling sandbags in front of the windows. Windows should be reinforced with wire netting or celluloid or strips of adhesive, and an oil-impregnated gasproof blanket hung inside the room

over the windows. Extraneous openings should be filled in with putty or plenty of wet newspapers or tight gummed strips. Colonel Prentiss suggests the following material in the room:

1. Tables and chairs.
2. Water for drinking and fire fighting.
3. Books, cards, toys, etc.
4. Fire buckets.
5. Hand pump for water and hose.
6. Sand and shovel.
7. Paper, paste, for covering cracks.
8. First-aid kit.
9. Dishes.
10. Canned food—can opener.
11. Food chest—airtight.
12. Sanitary facilities.
13. Spare blankets, etc.
14. Pick ax, shovel for clearing debris.
15. Electric grill for cooking and heating.
16. Flashlight—matches.
17. Mattresses, etc.
18. Radio.
19. Raincoat, gum boots, rubbers, etc.

It will be well to note the electric grill mentioned in the above list. Any form of burning, as with a wood stove or kerosene stove, will result in the use of all available oxygen and this closed room would soon become a death trap. Some provision should be made for a hand pump to force air through a canister and into the room. Any room tightly closed as this one would be must be provided with a constant supply of fresh air.

NON-COMBATANT MASK



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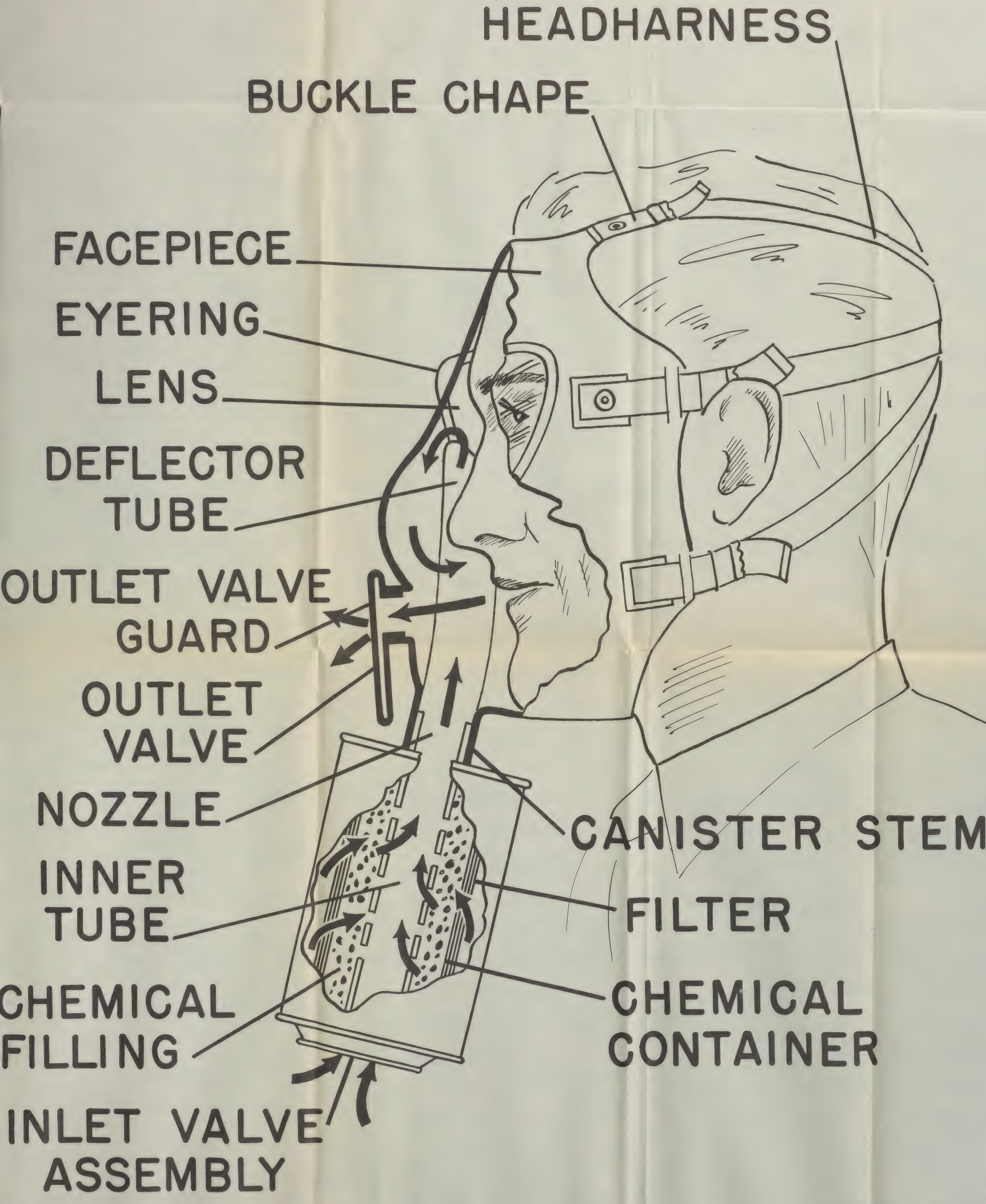
ARMY TRAINING MASK



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PROTECTION AGAINST GAS

UNITED STATES
OFFICE OF CIVILIAN DEFENSE
Washington, D. C.

THIS IS THE INSIGNIA OF THE DECONTAMINATION SQUADS
OF THE CITIZENS' DEFENSE CORPS

PROTECTION AGAINST GAS

Prepared by the WAR DEPARTMENT
With the Assistance and Advice
of Other Federal Agencies
December 1941

United States

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FOREWORD

Events abroad have amply demonstrated that civilians as well as a nation's armed forces must be prepared to withstand any means of attack that an enemy may employ. Among these is chemical warfare, commonly known as gas warfare.

If war gas were to be used in an attack upon this country, an enemy would probably act without warning in order to exploit the effect to the utmost. It is essential for civilian defense, therefore, that information and training be given in protection against gas. Thorough preparation is the surest way to reduce the number of casualties and perhaps even to discourage use of war gas entirely.

To this end, steps have already been taken by the Office of Civilian Defense. Specially qualified State and local officials are being trained in protection against gas as well as in other aspects of civilian defense. This training is being given at the Civilian Defense School at Edgewood Arsenal, Maryland, by the Chemical Warfare Service in accordance with arrangements made by the Office of Civilian Defense with the War Department. The graduates of this school, in turn, will instruct others in the identification of war gases, protective measures, and methods of decontamination.

The purpose of this textbook is to provide governmental agencies and others with essential information so that responsible authorities can make plans well in advance of any possible need. No requests should be made for gas masks or other protective equipment for civilians at this time. Information on these and related points will be issued at a later date.

This publication is expected to be used as the basic text for instruction of public employees and such volunteers as may be enrolled in the various specialized groups of the Citizens' Defense Corps.

F. H. LAGUARDIA,

U. S. Director Civilian Defense.

WASHINGTON, D. C., *December 1941.*

PROTECTION AGAINST GAS

Manual for the Instruction and Guidance of the Civil Population

"*Whether or not toxic gas will be employed in future wars is a matter of conjecture, but the effect is so deadly to the unprepared that we can never afford to neglect the question.*"—From Final Report of General John J. Pershing as Commander-in-Chief of the American Expeditionary Forces in the World War.

CHAPTER I. INTRODUCTION.

1. Purpose and Scope.

The purpose of this manual is to provide a general guide for civil communities in setting up an organization for protection against gas attack and in the training of gas-defense instructors and supervisory personnel. It aims to set forth in simple, readily understandable terms the nature of chemical warfare, the characteristics of the different types of war gases, including their effects on the human body, the means of their identification, and proper measures for protection against them. This book is not intended as a reference work for doctors and other medical personnel. The pathology of war gases and technique of treating gas cases are subjects dealt with in standard medical literature, including special publications of the Medical Department of the Army.

2. The Gas Danger.

Military operations today are no longer confined to more or less localized battlefields. The development of air forces and fast-moving armored units operating on land has made it possible to strike at "military objectives" deep in hostile territory. Thus, towns and cities far beyond the range of an enemy's field guns, especially areas of great importance as railway or supply centers, are now subject to attack. In these far-flung operations it is always possible that toxic gas may be used.

To reap the benefit of surprise, a nation bent upon making use of gas would try, in all probability, to conceal that fact until the moment of its employment. This might not be difficult. Indeed, preparations for chemical warfare are more or less easily concealed, since many of the war chemicals have commercial uses also and their manufacture, in limited quantity at least, is a normal industry.

Gas might be used in an attack upon a civil community either alone or in conjunction with other means. It is a reasonable assumption that the better the people are equipped and trained to deal with gas, the less the likelihood of it being used against them.

Quick-acting types of gases may be employed against a town or city to produce immediate casualties, throw the population into a state of panic and disrupt their defensive organization. Slow-acting chemicals, which may remain effective in liquid form for several days or more, may be used to "contaminate" important establishments such as factories, railway yards, docks, etc., so as to prevent their use or delay the repair of damage to them caused by demolition bombs. Such gases may also be used on city streets, or on roads and grain fields in rural districts to cause general havoc and casualties. They may be sprayed or sprinkled from airplanes, in the form of a fine rain, or used in bombs dropped therefrom (figs. 1, 2, and 3).

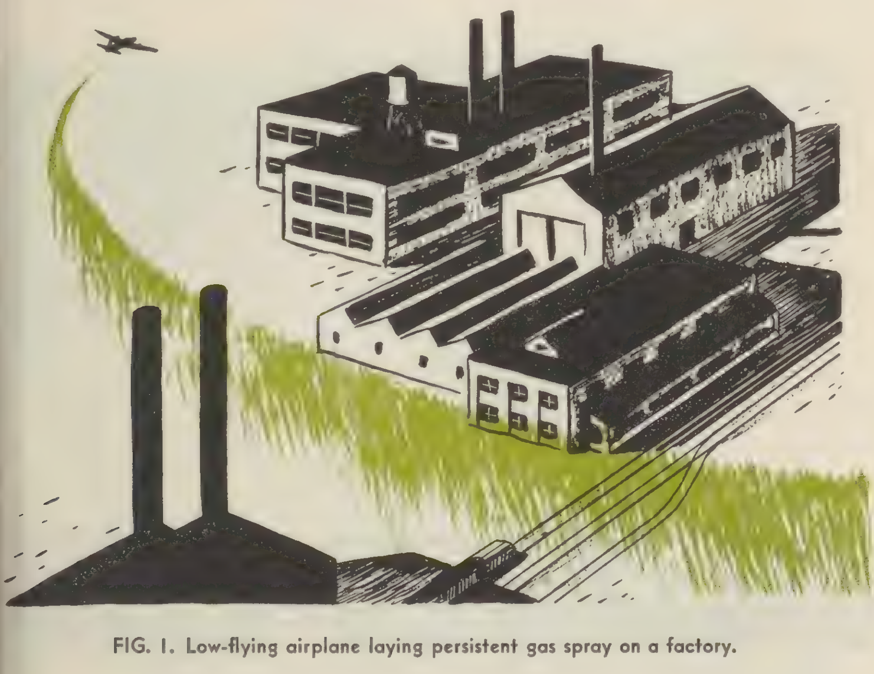


FIG. 1. Low-flying airplane laying persistent gas spray on a factory.

3. Limitations of Gas.

The vulnerability of any community, town or city, to gas attack depends largely upon its location. So great is the extent of this country that its vulnerability will vary greatly with different communities. It may be expected that, in the event of war, endangering any civil community in this country, the War Department will give timely warning to States which, in whole or in part, are considered to be in the zone of immediate danger.

But, aside from these considerations, it should be realized that there is necessarily a limitation upon the extent to which gas might be used. Despite the great increases in recent years in the cruising radius and carrying capacity of aircraft, the idea of a gas attack on such a scale as to wipe out the population of a large city, or even a large proportion of it, is still regarded as fantastic.

Even in limited areas, to be highly effective gas usually must be employed in great quantity. Few nations have the resources in raw materials and manufacturing capacity to wage chemical warfare on an extensive scale. Fortunately, the United States of America is well provided for in these respects, should occasion arise for its resort to chemical means.

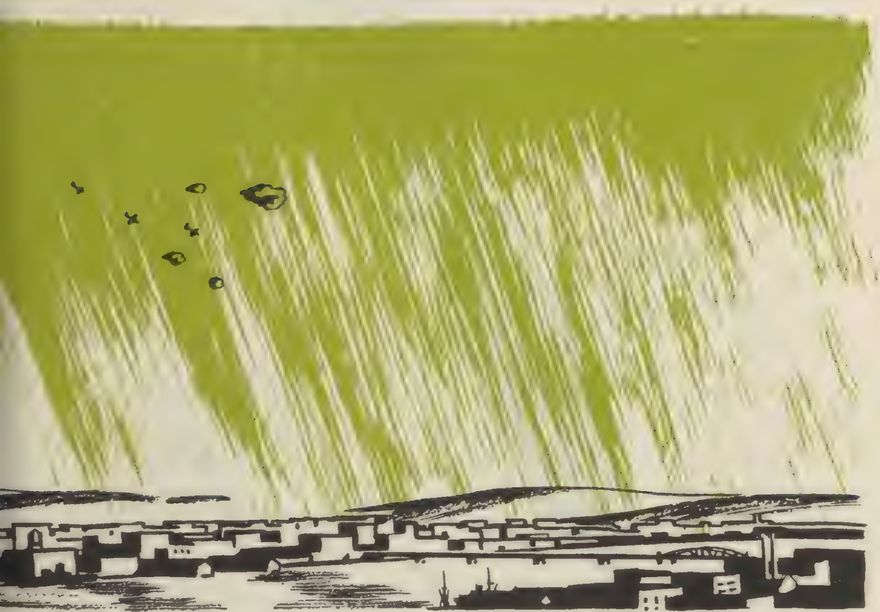
FIG. 2. Plane laying persistent gas spray curtain on a ctiy.

4. *The "New Gas" Possibility.*

There have been, from time to time, reports in the press concerning new, all-powerful gases against which, so it is said, existing means of protection would be entirely ineffective. Such stories may be regarded as unfounded. The consensus of military chemists is that the discovery and use of some new gas against which a modern gas mask would not give protection is very unlikely. There are many substances which, under certain conditions, are more injurious than known war gases but, for one reason or another, they cannot be used effectively in the open air. However, it cannot be said that the possibilities of chemistry have been exhausted. Throughout the world, both in Government arsenals and private laboratories, new chemical weapons, or new means of using existing ones, are constantly being sought. Thus, it is imperative for the national defense that research and development work on gas protective devices and measures be continued with unceasing vigilance.

5. *Why Training Is Essential.*

Probably the greatest danger in the event of a gas attack upon a



civil community is the likelihood of panic. Assuming adequate supply and distribution of gas masks, this can be avoided. There may always be some casualties but these may not necessarily be fatal.

However, when panic results from a gas attack, not only will there be a heavy toll in gas casualties, but many incidental injuries and fatalities from falls, trampling, and traffic accidents are inevitable. To prevent this, the mere provision of gas protective equipment is not sufficient. The people must be trained in the use of such equipment, have confidence in it, and overcome their fear of gas. Panic arises from fear, but knowledge and understanding dispel fear. In defensive preparations gas protective training is of the utmost importance.

Every adult person should have a fair knowledge of war gases, their action upon the body, the means of detecting their presence, and the first aid measures for those exposed to them. He should know what a gas mask is, how it works, and how to construct a simple but effective gas proof shelter in his home. It is desirable too that he understand "decontamination" or the process of getting rid of certain types of war chemicals which may be used and which are not quickly destroyed or removed by the natural action of wind and weather.

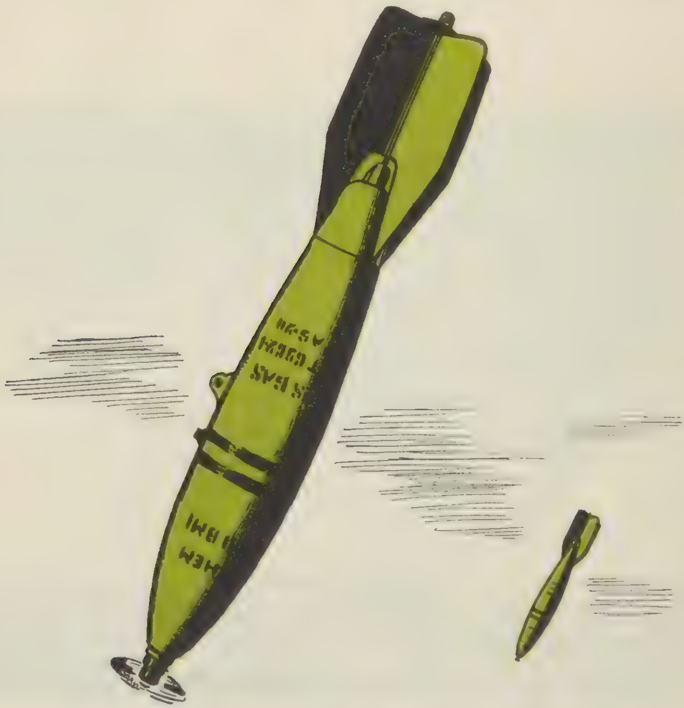


FIG. 3. Typical persistent-gas bomb dropped from airplane.

CHAPTER II. WAR GASES.

SECTION 1. CLASSIFICATION.

6. Nature of Chemical Warfare.

Chemical warfare is defined as a method of war in which substances are used for their direct chemical action to injure persons, or to produce screening smoke, or to set fire to combustible material.

The substances used for these purposes are referred to as chemical agents. Screening smokes, as such, are practically noninjurious. Incendiary materials and methods of combating them are dealt with in a separate Civil Defense pamphlet on fire fighting. We are concerned here only with those chemical substances used to cause bodily injury. These are all referred to as "gas" because they can be disseminated into the atmosphere in the form of a cloud, thus rendering the air at and about the target dangerous to breathe. The normal state of some chemical agents is a gas, but they may be compressed and liquefied for loading into artillery shells, airplane bombs or other containers. Upon release from their containers by an explosive charge or other means, these substances return quickly to their normal gaseous state. Other chemical agents are normally liquids, but they vaporize quickly enough after their release in the open air to form a gas cloud. Still other chemical agents are solid materials but can be disseminated in the form of a smoke or dust cloud in the air by means of burning or explosive munitions.

7. Persistency.

Chemical agents which are true gases and hence vaporize completely almost immediately upon their release are quickly acted upon by wind and air currents. The gas mixes with the air and is thus diluted so that in a short time it disappears entirely. Such gases are said to be nonpersistent. On the other hand, chemical agents which are normally liquids vaporize slowly after their release, giving off their toxic vapors for a considerable period of time. They are called persistent gases.

This distinction is easily understood if one compares these effects with those of familiar chemicals which are in common daily use. For example, consider the chemicals which one obtains for his motor car at a service station. If gasoline is spilled on the car or ground, it will

soon disappear by evaporation. It is less persistent than water, which, if spilled, will leave a wet spot for some time. On the other hand, if motor oil is spilled, it will remain for a very considerable period of time unless wiped off. It evaporates much more slowly than either gasoline or water and, therefore, might be called highly persistent.

War gases likewise vary greatly in their persistency and, in the case of any one of them, persistency varies with different weather conditions. In warm weather a substance evaporates faster, and, hence, is less persistent than when the weather is cool. Also, if there are winds or rising air currents, the agent will evaporate faster and be less persistent than when the air is comparatively still.

8. *Concentration.*

Another term which it is necessary to use in describing and explaining the effects of chemical agents is "concentration." This refers to the amount of the chemical which is present in a unit quantity of air. It is not something which the ordinary person can or need measure, but, if the odor of gas is sharp and strong, he will know that the concentration is high, and if the odor is faint, this usually is a good indication that the concentration is light. The more of a toxic or poisonous material present in the atmosphere, the more quickly and severely will one exposed to it be affected.

Everyone is familiar with such quantity effects in his ordinary experience. A large dose of medicine usually will have a much more

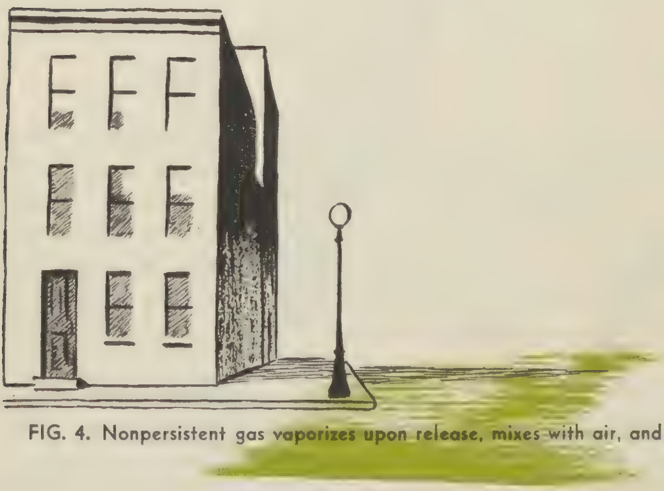


FIG. 4. Nonpersistent gas vaporizes upon release, mixes with air, and soon disappears.

drastic effect and will act more quickly than a small dose; but small doses, taken repeatedly, may in time produce the same effect as one big dose. This is true also of war gases. In the case of exposure to a war gas, the degree of injury depends both upon the concentration of the gas and the length of the period of the exposure. Thus a whiff or two of some gases may cause no injurious effect at all, but if one continues to breathe them, each breath of the substance adds its effect to that of the previous one so that, eventually the exposed person may be seriously hurt or killed.

We may say then, that a long exposure to a toxic gas in light concentration will tend to produce the same effect as brief exposure to the gas in high concentration.

9. Household Analogies.

It will help the average person in understanding these properties of war gases if he can be made to realize how similar they are to the properties of certain familiar substances in common household use. War gases usually are much more toxic or poisonous than any dangerous household chemicals, but they have much in common. Similarities in the matter of persistency have already been noted.

Consider now the effects of exposure. Everyone knows that gas used for heating or lighting is poisonous, and that if he turns on the gas jet in a tightly closed room and remains there, letting the gas escape, a high concentration will be built up so that he will be killed by asphyxiation. On the other hand, he knows that a few whiffs of

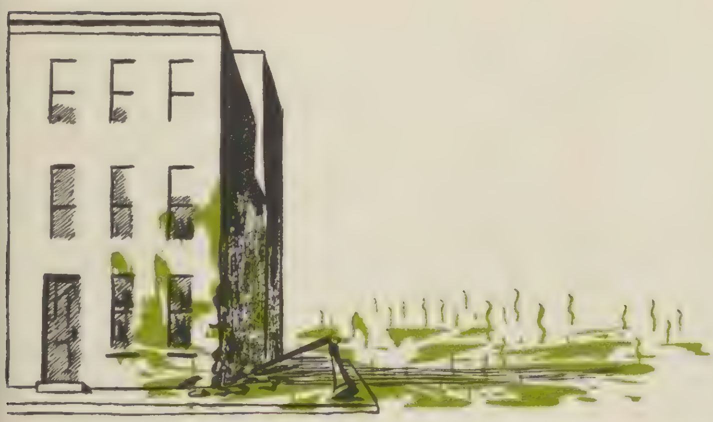


FIG. 5. Persistent gas vaporizes slowly and gives off toxic vapors for a long time.

such gas may make him sick, but will not kill him, or even cause permanent injury. Much of the same situation obtains in the case of exposure to a war gas. A person who has breathed some gas before he has been able to adjust his gas mask should not be overcome with fear and feel that he is going to die because he has been exposed. He should get his mask on as quickly as possible to prevent further exposure. He may suffer somewhat from the experience, but if the exposure has been brief, he may have no serious injury.

Again, everyone knows that if he drops some acid on his body it will produce a severe burn; or, if he exposes his bare skin to poison ivy, a rash, developing into itching blisters, usually is the result. These effects, though less severe, are not altogether different from the effects on the skin produced by exposure to mustard gas.

Still again, who has not suffered a smarting of the eyes, and perhaps of the nose, as a result of exposure to household ammonia or red pepper? These effects are not dissimilar to those of tear gases and certain other irritant agents.

10. Classification of Chemical Agents.

From the foregoing, it is evident that chemical warfare gases may be classified according to their physical state under normal conditions, according to their persistency, and according to their physiological action or the way in which they injure the body.

These classifications, with one or more examples in each class, are set forth below. The common name of each agent used as an example is given and, also, the brief chemical warfare symbol for the agent is shown in brackets.

a. *Physical state:*

- Gas—phosgene (CG); chlorine (Cl).
- Liquid—mustard gas (HS); Lewisite (M-1).
- Solid—The tear gas, chloracetophenone (CN); the irritant smoke, Adamsite (DM).

b. *Persistency:*

- Nonpersistent agents—phosgene (CG); chloracetophenone (CN) when used in burning type munitions; Adamsite (DM).
- Persistent agents—mustard gas (HS); Lewisite (M–1); tear gas solution (CNS); chlorpicrin (PS).

c. *Physiological action:*

- Lung irritants—phosgene (CG); chlorpicrin (PS); chlorine (Cl).
- Vesicant or skin-blistering gases—mustard gas (HS); Lewisite (M–1).
- Lacrimators or tear gases—chloracetaphenone (CN); tear gas solution (CNS).

Sternutators, or those that irritate the nose and throat and cause vomiting—Adamsite (DM).

Systemic (internal) poisons—hydrocyanic acid (HCN); carbon monoxide (CO).*

It should be realized that the preceding grouping according to physiological action is based only on the most pronounced effects. Most chemical agents share in some degree the injurious characteristics of others. Thus, almost all of them, if breathed long enough, will cause injury to the lungs.

A number of the chemical agents which irritate the eyes and cause some flow of tears are not classed as tear gases since they produce other and more serious injuries. Both mustard gas and Lewisite are deadly to breathe, but the fact that they injure any part of the body they touch, including the outer skin, causes them to be classified as vesicant or blistering agents, rather than as lung irritant gases.

11. Type Agents.

During and since the World War, many thousands of chemical compounds have been studied by chemists to determine their possible value for war purposes. Among these are many which are much more toxic or poisonous than those considered here, but injuriousness is not the only characteristic a substance must possess in order to be suitable for war use.

If the substance is to be used as a gas, this gas must be heavier than air so that, when released, it will not be immediately dissipated but will tend, for a time at least, to hug the ground. Thus, hydrocyanic acid gas and carbon monoxide, both extremely poisonous, are generally considered unsuitable for war use because they are lighter than air.

Again, if the substance is normally a gas, it must be one which can be liquefied readily and so loaded into shells, bombs, or other containers. It must be available in large quantities and easily manufactured. Not many substances possess all of these necessary properties for war use.

In this manual, no attempt is made to describe all of the chemical agents in each group. Only those which may be called "type agents" or typical of the group to which they belong are considered in detail. In general, if one knows the characteristics of the "type agent," he will know all he needs to know of all agents of that particular class.

*Not considered useful as war gases but typical of gases in this physiological group.

SECTION 2. TYPICAL EXAMPLES.

12. Lung Irritant Gases.

a. *Example.*—A typical example of this class of chemical agents is phosgene, symbol CG, which in concentrations producible in the open may cause death. Phosgene was used extensively in the World War. It is a nonpersistent gas and in open areas is usually dissipated within 10 minutes after its release. Being heavier than air, it tends to flow into low areas, in which places, especially in cool weather, it may accumulate and remain in effective concentration for an hour or more. If used on a city, it may be expected to accumulate in such places as areaways below the street level, cellars, etc.

FIG. 6. Physiological effects of chemical agents.
Lacrimators cause eyes to water and shut tight.

Sternutators irritate nose and throat, often cause headache, nausea, depression.

Lung irritants retard normal breathing, cause edema.

Systemic poisons absorbed in sufficient quantity may cause death.

Vesicants burn and blister the skin; lewisite causes arsenic poisoning.

b. How detected.—Phosgene can be detected by its characteristic odor. In low concentration this is sweetish and rather pleasant and generally is described as like that of green corn or new-mown hay. In high concentration the odor is less agreeable and somewhat like that of ensilage, or fermented fodder. Phosgene gas itself is colorless but a cloud of this gas may be perceptible to the eye. It appears whitish, like a thin smoke, due to the presence of condensed water vapor in the cloud.

c. How used.—Phosgene may be used in explosive shells or airplane bombs. It may also be released from cylinders in the user's own position when the wind is such as to blow the cloud to the target. Large clouds of this type may travel in effective concentration for several miles. The agent is highly injurious only if breathed; hence it may be expected that the user will seek surprise effect by producing an effective cloud quickly with a view to causing exposure before people can adjust gas masks. For this reason, phosgene attacks may well be expected at night. Cool, cloudy weather favors the use of this type of gas. High winds and rain are unfavorable for its use.

d. Effects on the body.—When breathed, phosgene acts directly upon the lungs, causing the air cells to fill with fluid from the body. The normal process of respiration, in which oxygen is transmitted from the air to the blood, is thus retarded or stopped entirely. If the concentration of the gas is high, casualty effect usually takes place rapidly after brief exposure. If the concentration is low, the physiological effects frequently are delayed.

Catching of the breath, coughing, and choking, usually follow the breathing of phosgene. Sometimes there is vomiting. These symptoms may shortly disappear and for several hours afterward the victim may feel well and thus not realize that he is injured. However, if the lungs have been seriously affected, these symptoms will return and in more violent form. As a rule, if there is no return of such symptoms within 24 hours of exposure, the affected person can be regarded as out of danger.

A person exercising, or merely standing erect, requires much more oxygen to sustain life than one lying at complete rest. Since lung injury, due to breathing phosgene or similar gases, reduces the capacity of the lungs to supply oxygen, it is manifest that such a gas victim should be placed at complete rest at once. The gravest danger of sudden collapse and possibly death is incurred when a person who has been exposed, disregarding or not realizing his injury, continues to exert himself. In addition to its effect on the lungs, phosgene also irritates the eyes, causing the flow of tears.

e. Effect on material.—Phosgene in high concentration, especially if moisture is present, has a corrosive action on metals. Food exposed to it may be contaminated.

f. Protection required.—A modern gas mask provides complete protection against phosgene and all known agents of its class.

g. First aid.—A person who has been exposed to phosgene should be placed at complete rest, kept warm, and given light stimulants such as hot coffee or tea. Medical aid should be sought as soon as possible. (See Ch. III for further details on first aid.)

13. Vesicant or Blistering Gases.

a. Example.—The outstanding example of this type of gas is mustard gas, symbol HS, which in concentrations producible in the open may cause death. Mustard gas is an oily, slowly evaporating liquid, characterized by its vesicant or blistering action. It is highly persistent. The period during which it will remain effective after its release will vary from several hours to several weeks, depending upon the temperature, the amount of the substance, and the way in which it is used. Mustard gas will permeate any material which is at all porous, rendering it dangerous to touch, until decontaminated. Likewise, mustard gas will adhere to and contaminate metal surfaces.

b. How detected.—Mustard gas has a characteristic odor which is very much like that of garlic. The sense of smell, however, soon becomes fatigued by this odor so that, after a time, if exposure to low concentrations of the gas is continued, the presence of the gas may not be noticed. A somewhat similar agent, Lewisite, has the distinct odor of geraniums. Liquid mustard gas, splashed or sprayed on vegetation and light-colored surfaces, shows as brownish spots. The vapor itself is invisible.

c. How used.—Mustard gas and similar agents may be disseminated by means of explosive shell or airplane bombs or they may be sprayed in the form of a fine rain from containers carried on aircraft.

d. Effects on the body.—Even in very low concentration, mustard gas has a very serious effect upon the eyes, causing irritation and, frequently, temporary blindness. The vapor of the mustard gas will quickly penetrate ordinary clothing, causing burns upon the skin, particularly at moist, delicate parts such as the armpits. A small droplet of the substance in liquid form, sufficient merely to cover the head of a pin, will cause a severe burn. The casualty effect of mustard gas is delayed usually from four to six hours after exposure in the case of the vapor, and from one to two hours in the case of the liquid substance.

The first symptom of skin burns usually is itching. This is followed by a rash which changes later to watery blisters and, possibly,

a deep wound. Unless a great amount of the skin surface is thus affected, such wounds are rarely fatal unless infected, nor do they usually cause permanent injury, though long periods of hospital treatment are required to cure them.

Mustard gas burns generally do not cause much, if any, pain. The breathing of mustard gas vapor results in general inflammation of the entire respiratory tract and renders the victim highly susceptible to pneumonia. In cases of fatal mustard poisoning, death usually is the direct result of pneumonia from breathing the gas.

The effects of the somewhat similar agent, Lewisite, are similar, but the action of Lewisite is considerably quicker. Moreover, Lewisite contains arsenic and, unlike mustard gas, is absorbed into the bodily system, producing arsenical poisoning.

e. *Effect on material.*—Mustard gas and similar agents contaminate materials exposed to them, rendering them dangerous to touch. (See Ch.IV on decontamination.)

f. *Protection required.*—In addition to the gas mask, special clothing is required for protection of the body against mustard gas and similar agents. It is not practicable, nor is it considered necessary, for all of the people to be provided with such clothing. Persons charged with decontamination work or other duties requiring them to remain in gassed areas should be equipped with it. (See Chs. III and IV.)

g. *First aid.*—Persons who have breathed mustard gas should be treated as lung irritant cases. Their clothing, if contaminated, should be removed as soon as possible and they should be bathed with water and soap. In case liquid mustard has come in contact with the body, protective ointment or a paste of bleaching powder and water should be applied to neutralize the mustard and then removed (in a few minutes). If redness or blisters has already developed do not use bleaching powder or ointment. In this case, or if they are unavailable for normal decontamination, the affected area should be cleaned with kerosene, gasoline, carbon tetrachloride or alcohol, care being taken not to spread the contamination. Following this, hot water and soap should be used. (See Ch. III.)

14. Nose and Throat Irritants (Sternutators).

a. *Example.*—These agents, sometimes called sneeze gases, are also frequently referred to as toxic or irritant smokes, since they are not disseminated as gases but rather in the form of a cloud of minute solid or liquid particles. Such clouds are nonpersistent. Typical of this group of agents is a substance known as Adamsite, symbol

DM. It is a solid material which is disseminated by a burning process. There are similar agents which can be used in explosive shells or bombs.

b. How detected.—Adamsite has no distinctive odor. It is sometimes described as rather like that of coal smoke or burning smokeless powder. The cloud given off from munitions containing Adamsite is canary yellow in color but, after traveling a few hundred yards, becomes invisible.

c. How used.—Irritant smoke agents may be used in burning type munitions called candles or, in the case of certain types, in shells or airplane bombs containing an explosive charge. In the latter case, it may be difficult to distinguish the bursting shells or bombs from ordinary high-explosive types. The particles which make up clouds of these agents will not penetrate a gas mask which is provided with a suitable type of mechanical filter.

These agents are effective in very low concentration. Brief exposure to them may cause such immediate distress as to keep victims from adjusting their gas masks or cause them to remove their masks afterward. A high state of "gas discipline," developed by training, is required to prevent this. It must be realized that an attack with agents of this type is likely to be followed by the use of a more deadly gas such as phosgene.

d. Effects on the body.—Irritant smoke agents affect particularly the nose and throat, causing irritation. Headache, nausea, and severe mental depression are also frequent symptoms. Casualties caused by these substances are rarely fatal, but the victim may be incapacitated for 12 hours or possibly longer.

e. First aid.—The victim should be put at rest and his gas mask kept on until he is removed to a gas-free area. Spraying of the nose and throat with soda or boric acid solution and allowing the patient to inhale, lightly, chlorine gas given off from chloride of lime are helpful. Clothing should be loosened. If the case is severe, the patient should be removed to a hospital. (See Ch. III.)

15. Tear Gases.

a. Example.—There are a number of agents of this type, the principal effect of which is to irritate the eyes, causing a copious flow of tears. All of them are highly effective in very low concentration. Some are liquids and some are solid materials.

Chloracetophenone, symbol CN, is typical of the group. It is a solid crystalline substance which, when evaporated by the application of heat, gives off its irritating gas. So used the agent is nonpersistent. The substance may be dissolved in liquids and used in explosive munitions or in airplane spray apparatus. In such cases it is persistent, and considerably more severe in its effects.

b. How detected.—Chloracetophenone has a rather sweetish pleasant odor, frequently described as like that of apple blossoms. However, the action of the gas on the eyes takes place so rapidly, that frequently this odor is not perceived.

c. Action on the body.—Tear gases act directly upon the eyes, causing irritation which results in a copious flow of tears. In such concentrations as usually are obtained in the open, the effects of these gases are transitory.

d. How used.—Tear gases may be used in explosive shells, bombs, and grenades, and certain liquid types may also be sprayed from airplanes. Such gas may be employed alone or in conjunction with high explosive munitions. It is used to harass, force the wearing of gas masks. If used against a city, the purpose would probably be to cause confusion and delay and lower the morale of the people.

e. Protection required.—The gas mask furnishes complete protection against all agents of this type.

f. First aid.—Usually, all that is necessary after exposure to such gas is to leave the gassed area and face the wind. The eyes should not be rubbed. In severe cases, the application of cold water or boric acid solution is desirable. (See Ch. III.)

16. Systemic Poisons.

a. Examples.—Although not immediately irritating to the skin, eyes, nose, or lungs, these gases cause systemic (internal) poisoning, and if inhaled in sufficient quantity, may cause death. No such gases suitable for war purposes are now known, but the possibility of their being discovered cannot be disregarded.

Hydrocyanic acid gas (HCN), familiarly known as prussic acid gas, having an odor like bitter almonds, is an example of gases in this group. Unlike other gases described herein, its action is not cumulative or progressive, a definite concentration of the agent being necessary to produce any effect. Brief exposure to such a concentration, however, usually has fatal result. HCN was tried in the World War but was discarded. It is lighter than air and thus is quickly dissipated after its release.

Another agent in this general class is carbon monoxide (CO), which is odorless. It, too, is not classed as a war gas but is sometimes encountered in war, being one of the products from the explosion of high explosive bombs and shells. It is also present in coal gas used for cooking and heating in many cities. There is no danger from this gas in open areas but, where a bomb or shell explodes in a building or other enclosed space, or when a broken main permits it to seep into a cellar, a concentration of this gas sufficient to be dangerous may result.

b. First aid.—Effective first aid treatment for exposure to either of these two gases generally involves the administration of oxygen. The modern gas mask for war use protects against HCN but not against CO.

17. Chart of War Gases.

Descriptive data concerning "type agents" and other well known gases in each of the physiological classes are given in large chart in pocket on inside of cover.

18. Uses of Gas

The intentions of the enemy with respect to a city or town subjected to gas attack may be indicated by the type of gas and the manner of its use. For example, if he wished to disorganize a city with a minimum of material damage, he might try to gas it. In case he planned an immediate occupation, he would use a nonpersistent type of war gas which would cause casualties. If he did not intend to occupy the city or intended to delay his occupation of it for several days, a persistent chemical agent might be used.

In any event, it is practically certain that an enemy will avoid entering any area contaminated by persistent gas. If the enemy's purpose were to harass and lower the morale of the populace, he might use tear gas. If a nonpersistent gas is used, it is likely that the bombardment will be sudden and intense but of short duration, since such gas only injures persons exposed before they can adjust their masks. However, an attack of this nature is likely to be repeated later on. If persistent gas is used, the bombardment may be slow and deliberate, since surprise effect is not essential for positive results.

SECTION 3. EFFECT OF WEATHER AND SURROUNDINGS ON GAS

19. *War Gas Hugs the Ground*

Gases, to be suitable for war purposes, must be heavier than air. If lighter than air, they are so quickly dissipated after their release that an effective concentration of them cannot be developed. Since war gases are heavier than air, they tend to hug the ground. They mix with the air, becoming in time more and more dilute and finally disappearing entirely. These heavy gases flow downhill more or less as does water and tend to accumulate in low lying places. In open country, they will accumulate and remain effective in ravines and gulleys for a considerably longer time than they do over high, open ground. Likewise, they will persist longer in woods than in open areas.

If used against towns and cities, gas may be expected to accumulate in subways, cellars, sewers and other such low lying places in a city. It therefore is evident that persons on the upper floors of buildings might be entirely safe, whereas those at ground level would be exposed to a higher concentration. Even the upper floors of a two or three story house are considerably safer in this respect than a lower floor or cellar. On the other hand, the lower floors or cellars are usually considered safer places of refuge against high explosive bombs. These conflicting factors must be taken into account in providing places of refuge against attack.

Gas tends to pass around and over a house if doors and windows are closed. However, unless all cracks and crevices are sealed, the gas will eventually penetrate the house.

20. *Wind.*

Gas clouds move with the wind. Low velocity and steadiness of the wind are favorable for the use of gas. Under such conditions a gas cloud tends to remain intact and the enemy may then make use of the wind to blow the gas over the target. However, if the wind velocity is high, more than 10 or 12 miles per hour, or if the wind is gusty, the gas cloud is torn apart and quickly dissipated.

21. *Rising Air Currents.*

When the sun shines brightly, the ground surface becomes warm and radiates heat, causing rising currents of air. This is very pro-

FIG. 7. War gases being heavier than air accumulate in low places such as valleys, cellars, and subways.

nounced in warm weather and is one of nature's most potent means of ridding the atmosphere of any pollution. In this connection, it should be realized that only for a limited period will any chemical agent released in the open sunshine remain effective.

At night, when the ground is cool, rising air currents are less pronounced than during the daytime and may even be totally absent. For this reason, as well as because of the greater opportunity at night for surprise effect, gas attacks may particularly be expected at night.

22. *Rain.*

A heavy rain is fatal to almost any gas attack. In the case of some agents, such as phosgene, the gas is destroyed by chemical action with the rain water. Gas of any type is beaten out of the air by the rain drops and drained away if not chemically destroyed. Fogs or mists, however, will not appreciably affect gas clouds and may even favor the use of gas since at such times wind and rising air currents usually are absent.

23. Clouds.

Cloudy, overcast skies favor the use of gas since such conditions are not conducive to rising air currents.

24. Temperature.

The warmer the weather, the more quickly chemicals are vaporized; and the more quickly this happens, the sooner they are dissipated. Thus, in general, cool, cloudy weather is favorable for their employment.

However, an exception is to be noted in the case of such highly persistent agents as mustard gas. Warm weather accelerates the

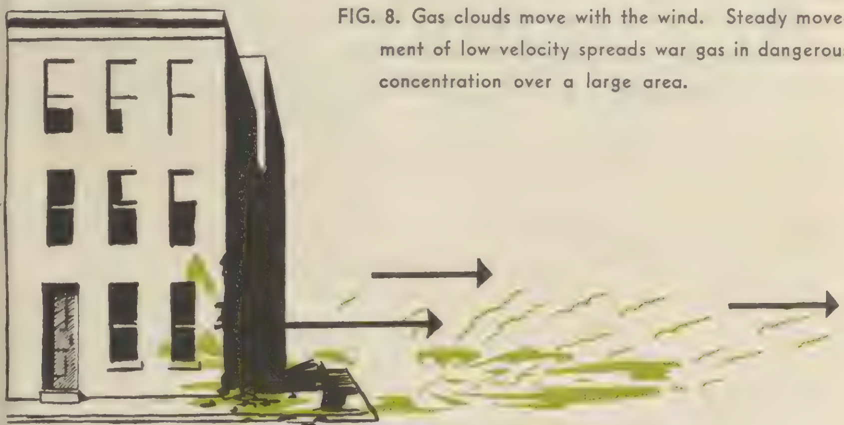


FIG. 8. Gas clouds move with the wind. Steady movement of low velocity spreads war gas in dangerous concentration over a large area.

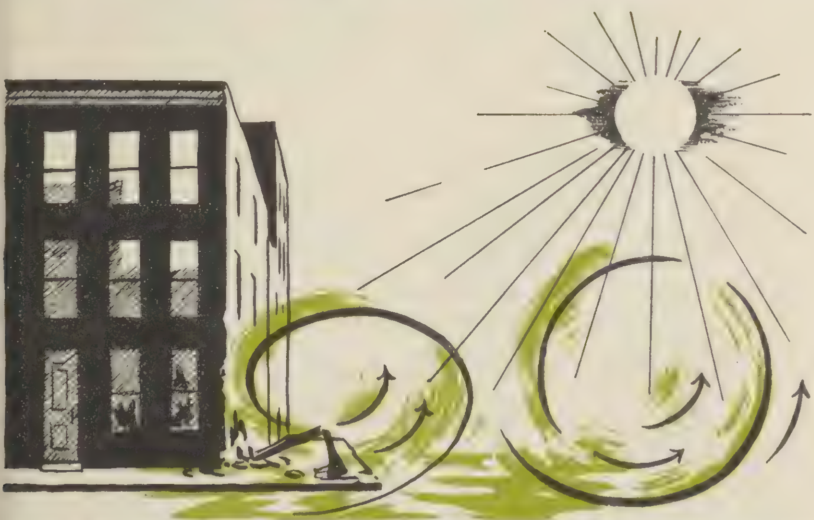


FIG. 9. Bright sunshine causes rising currents of air that help to disperse concentrations.

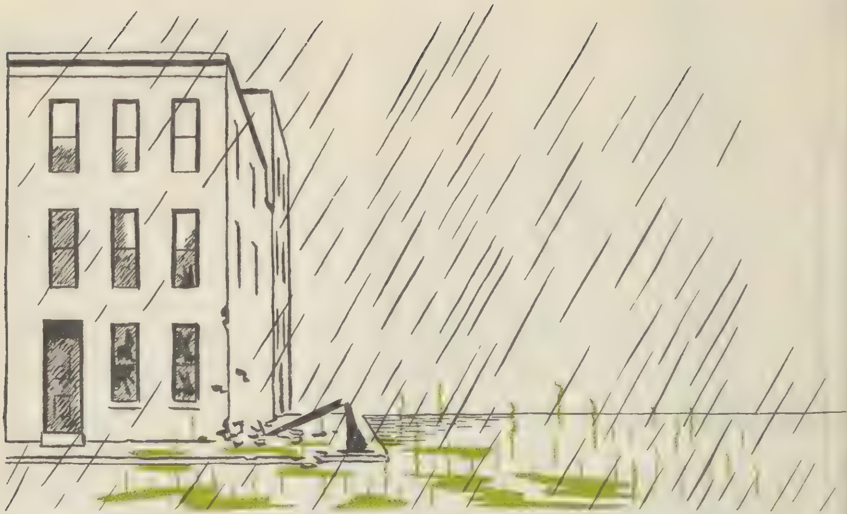


FIG. 10. Rain helps destroy any type of gas and washes liquid away. Mustard gas, however, is hydrolyzed slowly.

evaporation of these particular agents, thus producing a higher vapor concentration of them than obtained when the weather is cool.

Mustard gas will freeze at a temperature considerably above the freezing point of water, which is 32° Fahrenheit, and thus remain inert, but as soon as the temperature rises sufficiently, it will melt and again give off its toxic vapors.* Frequently, such gas, released at night when the air and ground are quite cool, gives off very little vapor so that no gas may be perceived; however, when the sun comes out and the temperature rises, a considerable concentration may be developed.

* Freezing point of crude mustard gas, depending upon impurities present, varies from 46° to 50° F.

CHAPTER III. INDIVIDUAL PROTECTION.

SECTION 1. CLASSIFICATION OF PROTECTIVE MEASURES.

25. Classification.

Passive defense against gas attacks involves two classes of measures, individual and collective.

a. Individual protection.– Individual protection pertains to the provision and use of gas masks, gas protective clothing, training in the identification of gases by their odors or by other means, and in first aid measures for treatment of gas casualties.

b. Collective protection.—Collective protection pertains to the provision and use of equipment to protect a number of persons as a group. This subject is discussed in chapter four.

SECTION 2. GAS MASKS.

26. Types and Functions.

A gas mask is a device which is worn over the face to protect the eyes, respiratory passages, and lungs from toxic gases, irritating gases, and smoke present in the atmosphere.

There are many different types of gas masks. Some of them, used in industries, are designed for particular purposes, for instance , to protect against ammonia fumes in refrigeration plants, or for protection against high concentrations of certain gases used for fumigation, or to protect firemen against carbon monoxide likely to be encountered in burning buildings. These special gas masks are not designed for protection against war gases and should not be used for that purpose. Likewise gas masks for war use are designed to protect solely against war gases.

It should be realized also that gas masks do not supply air. They merely filter and purify air which is drawn through them. They are not designed for use in places such as mine shafts, etc., where there may be a lack of sufficient fresh air. For protection in any such places a self-contained oxygen breathing apparatus or a mask provided with a long hose extending to the outside should be used.

27. *Masks for War Use.*

A modern gas mask for protection against war gases consists of two essential parts—the facepiece and the canister. The facepiece, which is made of rubber or other suitable material, is designed to fit the face closely so that when the mask is worn no air is breathed except that which is drawn through the canister. The facepiece is provided with lenses for vision and a one-way air outlet valve to permit passage of expired air.

An elastic head-harness is attached to the facepiece to hold it in place. The canister is attached to the facepiece. It contains granules of specially prepared and treated, highly porous carbon called activated carbon. Activated carbon has the peculiar property of attracting and holding war gases but at the same time allowing the pure air with which such gases are mixed to pass on through into the facepiece. Granules of specially prepared soda lime may be mixed with the carbon to provide additional chemical protection against some gases.

In addition to the activated carbon and soda lime granules, the canister contains a filter made of fibrous material which stops any of the minute solid or liquid particles of which irritant smokes are composed. Thus the mask provides complete protection against any type of air-borne chemical agent which, so far as is known, may be used as a war gas.

After continued use in an atmosphere where gas is present the canister may become "saturated" so that it will retain no more gas. It is then unserviceable and should be replaced. However, under ordinary conditions the canister will fail gradually, allowing only very small amounts of gas to pass through it before it will permit a dangerous amount of gas to pass. A trace of gas can be detected by its odor or irritating effects and will thus give warning that the canister should be replaced. Masks made to meet U. S. Army specifications may be relied upon to protect the wearer against any gas attack that may be expected.

28. *Civilian Masks.*

Among the types of gas masks used in the Army there are two which are considered suitable for use of civilians. These types are known in the Army as:

a. The Noncombatant Gas Mask.
b. The Training Gas Mask.

29. The Noncombatant Gas Mask.

The facepiece of this type of mask is made of gas resistant fabric. The facepiece of the mask for adults is designed to fit any size and type of face. Small and medium sizes of facepieces are required for children. The head-harness consists of six elastic straps. Two lenses are sewed in place, and there is an outlet valve on one side of the facepiece. The canister has a rubber inlet valve on the bottom attached to a metal disk. This valve permits air to pass in but not out. The principal parts as well as the air flow system of this type of noncombatant mask are shown in figure 11.

The mask is carried in a canvas bag provided with a closure and a shoulder strap. This type of mask can be manufactured in quantity at low cost. For the Army's purposes such masks will be provided to civilians whose duties require them to remain in the theater of operations.

30. Respirators for Children and Infants.

In certain foreign countries which have had occasion to make very extensive provisions for gas protection, special respirators have been designed for very small children and infants. The small child's respirator is similar to the gas mask for adults but is of course smaller. The facepiece is usually made of soft rubber. For babies, a protective helmet is provided. This consists of a bag covering the entire upper part of the body. A canister with bellows is attached so that purified air can be pumped into the bag. A large window made of transparent material permits the baby to see. In general, rather than to rely on these devices for protection of small children, it is considered desirable to evacuate them from cities to less vulnerable areas.

31. The Training Gas Mask.

This type of mask is fundamentally the same as the noncombatant mask but is more rugged in construction. The facepiece is made of rubber, and the eye lenses and canister are replaceable. The canister of this mask is the same as that of the noncombatant mask. This mask is used in the Army for training purposes, being considerably less costly than the Service Mask provided for the soldier for war use. This type of mask is considered particularly suitable as a "Civilian Duty Mask" for use by civilian decontamination squads, policemen, firemen, etc., whose duties in civil defense activities may make it desirable to have a somewhat more durable mask than the noncombatant type.

FIG. 11. Noncombatant gas mask.

32. How to Adjust the Gas Mask.

1. How to Adjust the Gas Mask.

a. As soon as the odor of gas is detected, or upon hearing the gas alarm, stop breathing and hold the breath.

b. Remove hat and eyeglasses.

c. Place the left hand around the bottom of the carrier at the canister, open the cover flap with the right hand, and remove the mask.

d. Bring the mask up in front of the face. Grasp the facepiece in both hands with the thumbs inside and below the lower head-harness strap and with the fingers on the outside of the facepiece. Open up the mask with the thumbs.

e. Thrust the chin up and out. Pull the mask over the chin and then over the rest of the face.

f. Pull the head harness down into position on the back of the head. Adjust the mask on the face. Women must first brush the hair back so that the mask will rest on the face; otherwise, gas may enter around the edges of the mask. Similarly, men who are not clean-shaven may not get a gastight fit.

g. Place the left hand over the outlet valve and exhale as strongly as possible, emptying the lungs. This important operation forces out any gas which may have been inside of the facepiece when it was put on.

h. Start breathing normally. Replace the hat and close the flap of the carrier.

II. How to Test for Gas.

a. Even though the "all clear" signal has been given, always test for gas before removing the mask. To do this, first take a moderately full breath of air. Exhale a portion of the air breathed and stop breathing.

b. Stoop down and bend forward so as to bring the head as close to the ground as possible, but do not lose the balance or touch the ground with the hands or knees.

c. Insert two fingers of the right hand between the face and the facepiece at the cheek, thus permitting air to enter the facepiece. Sniff gently but do not inhale.

d. Stand up again. If no gas was detected, remove mask. If gas was detected, clear mask as described in paragraph g.

III. How to Remove the Gas Mask.

a. Grasp the canister just below the facepiece with the right hand.

b. Bend the head slightly forward and pull the mask outward and upward and off the head.

c. Hold the mask in the right hand and fold the head harness inside.

d. Replace the mask in the carrier and close the flap.

IV. How to Adjust the Head Harness of the Gas Mask.

a. Loosen the straps as much as possible.

b. Put on the mask. Tighten the straps, making certain that the straps on opposite sides of the mask are tightened equally.

c. Test for leakage by placing the palm of the hand lightly over the outlet valve on the bottom of the canister and breathing in. The facepiece should collapse on the face. If the fit is too loose, or if there is a hole in the facepiece or canister, leakage will occur and the mask will not collapse on the face.

d. Continue to tighten the straps until the fit is airtight. However, if the fit is too tight it will be uncomfortable.

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V. How to Inspect the Gas Mask.

a. Examine the facepiece carefully for pinholes, cracks, or tears by holding it up to a strong light. Examine the chin seam for rips or tears and the chin seam tape for any sign of failure. If examination indicates any need for repairs, take care of the mask at once by stopping the leak with adhesive tape.

b. Examine the head-harness buckles for breakage and the straps for tears.

c. Examine the outlet valve. The rubber disk must not stick to the valve seat. It must retain its elasticity. If it has hardened, cracked, or taken a permanent set, it must be replaced.

d. Examine the inlet valve on the bottom of the canister. It too must be flexible. If it has hardened, it must be replaced.

e. Examine the carrier for holes, tears, or other signs of wear.

VI. Disinfection of the Gas Mask.

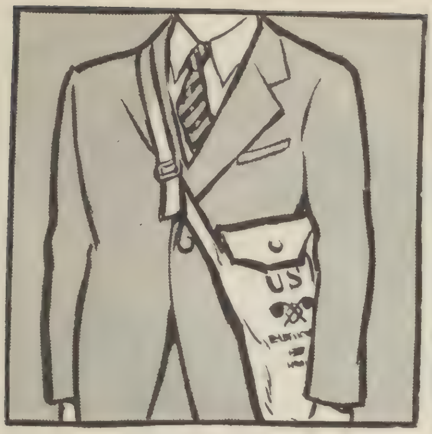
A mask should be disinfected occasionally, and in every case before it is used by a person other than the original wearer. A three-percent solution of formaldehyde (USP solution) or similar disinfectant is used. The mask must be held upside down, that is, with the canister above the facepiece, to prevent the disinfectant from getting into the canister. This is done with one hand. The other hand is used to sponge the entire surface of the facepiece both inside and out with a small piece of clean rag which has been saturated with the disinfectant; some of the liquid should be poured into the outlet valve. Any excess liquid is drained out by opening the valve.

After drying fifteen minutes in ordinary air the inside of the facepiece is then wiped with a clean cloth to remove any remaining moisture. When the mask is thoroughly dry it is returned to the carrier.

VII. Care of the Gas Mask.

The mask should be kept in the carrier when it is not in use. Nothing else should be put in the carrier nor should any weight be put on it. While at home or at work the mask must be kept in a cool dry place. It must not be placed near a radiator. The canister must be kept dry. If the mask is worn during a rain, it should be dried before being replaced in the carrier. If the canister becomes wet, it must be replaced at once. In time of emergency the mask should always be kept handy in its carrier. When sleeping, the mask should be near the head of one's bed.

Always take good care of your gas mask and keep it ready for use. If you encounter gas, it will save your life.



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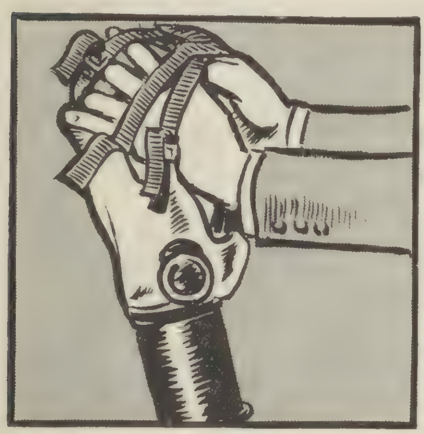

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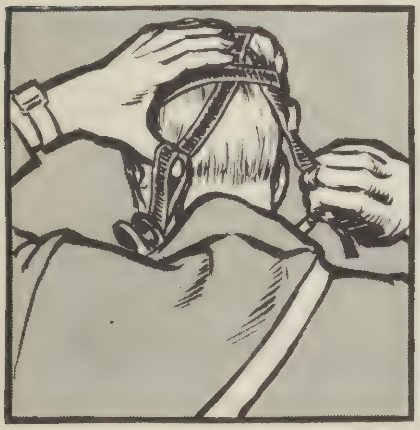

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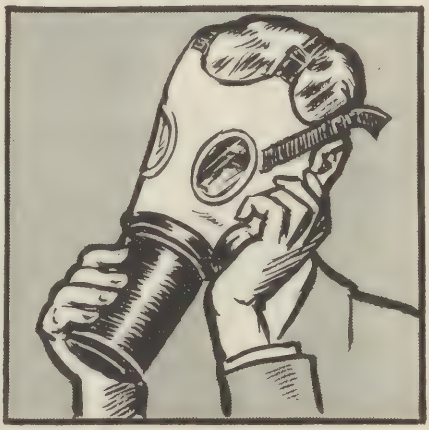

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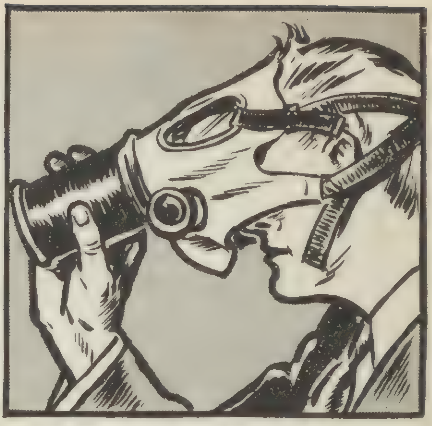

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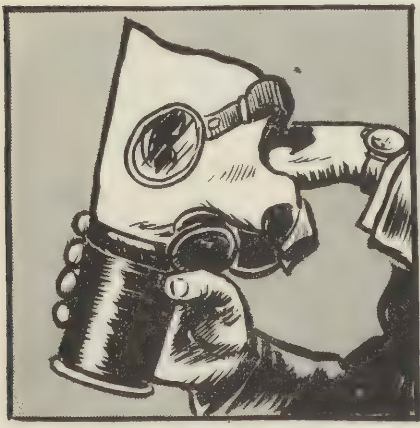

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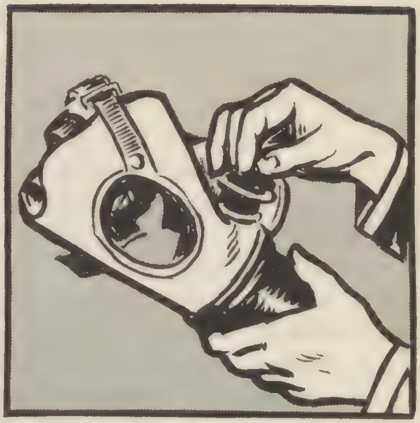

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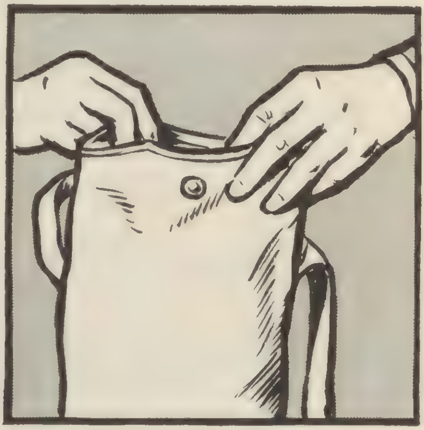

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SECTION 3. PROTECTIVE CLOTHING.

33. Description and Purpose.

For protection of the body against vapors or droplets of vesicant gases, persons must either take refuge in a gasproof shelter or wear protective clothing. (Gas shelters are described in the next chapter.)

Protective clothing consists of garments made of materials which prevent vapors of mustard gas and the like, or droplets of liquid chemical, from passing through them and coming in contact with the skin. It is needed by decontamination squads and other protective personnel whose duties may require them to work in contaminated areas.

To be effective the clothing must cover the entire surface of the body, and all seams and fastenings must be gastight. There must be no holes or tears. Such clothing used in the Army is of the coverall type. Attached to the suit is a hood, which when adjusted covers the head and fits snugly around the edge of the gas mask facepiece. Straps are provided to tighten the sleeve about the wrists and the legs of the garment at the ankles. Rubber or oilskin type gloves, rubber boots, or specially treated leather shoes, complete the equipment.

The coverall made of oilskin type material is not only resistant to penetration by mustard gas or similar agents, but also is impervious to air. In consequence such clothing can only be worn with safety for limited periods. It interferes with evaporation of perspiration from the skin, so that the individual becomes overheated. To continue wearing it then is dangerous to health. These effects are more

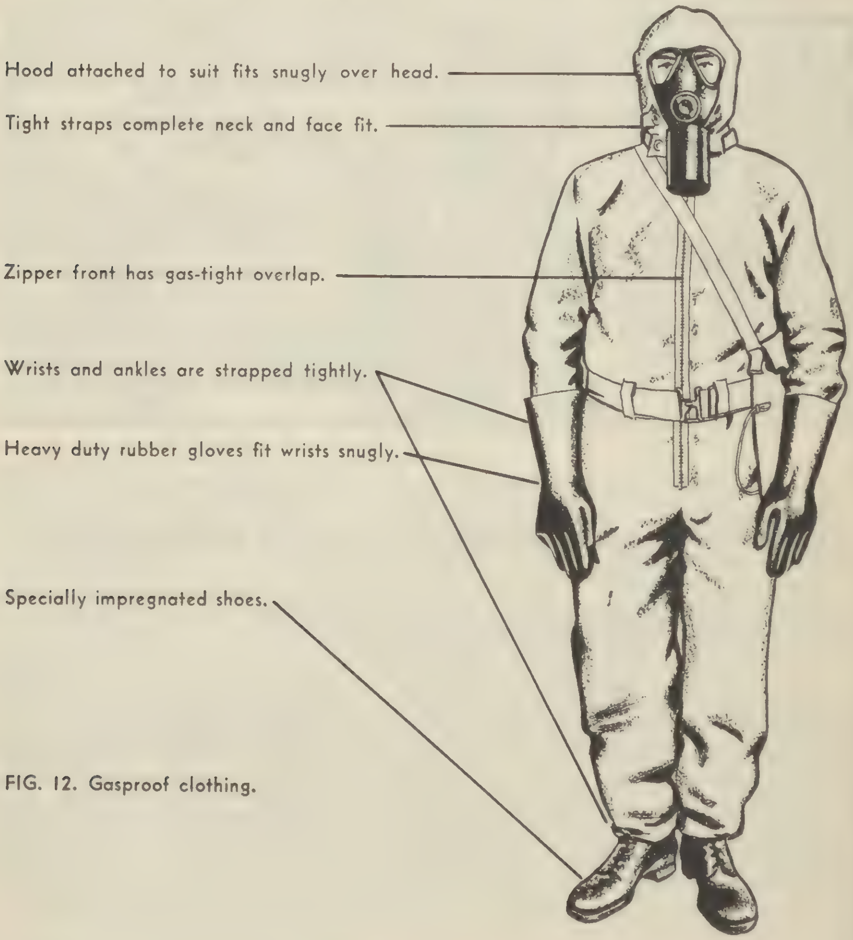


FIG. 12. Gasproof clothing.

pronounced in summer than in winter. In general, it is considered that continuous wearing of such clothing should not be extended beyond two hours; in the summer, it may be intolerable after less than ten minutes.

34. Adjustment.

It is difficult for the wearer of such a gas protection suit to adjust the closure of the garment himself; consequently, personnel required to use protective clothing should be trained in aiding each other in this respect. Aid is also necessary in removing the clothing if it is contaminated; otherwise, the wearer is likely to touch contaminated portions and receive a burn. Contaminated clothing must be carefully handled to avoid spreading the contamination and must be decontaminated before it is used again. Before putting on the protective suit, the wearer should remove his ordinary clothing and put on a clean suit of long underclothing and clean socks. (See Ch. IV, Sec. 4, Decontamination.)

SECTION 4. IDENTIFICATION OF GASES.

35. Chemical Gas Detectors.

Ever since the introduction of the use of gases in warfare, chemists have been searching for a universal war-gas detector, or a device which by chemical means will definitely indicate the presence of war gas. There have been developed special kinds of colored paper, powders, and paints which undergo well-defined color changes when liquid mustard or Lewisite strike them. These detectors are suitable for mustard or Lewisite, but as yet no universal detector has been developed.

36. Sensory Detection.

The human nose is a very delicate organ, and the average person, with proper training, can distinguish all of the known war gases by their odors. (See table 1, following.) A knowledge of the symptoms of injury caused by exposure to the various agents and of the appearance of gas clouds may also aid in identifying any gas used.

The odor of anything can only be described as like or similar to the odor of something else. This resemblance, in some cases, may be rather faint. Moreover, no one can know exactly how anything will smell to him until he actually smells it. Everyone, if possible, but especially those persons designated to give warning of gas attacks, should be familiar with the odor of each war gas.

Table 1.—Identification of Chemical Agents

AGENT	SYMBOL	ODOR	OTHER IMMEDIATE EFFECTS*
Mustard Gas	HS	Garlic, horseradish	None.
Lewisite	M–1	Geraniums	Sneezing; eye irritation.
Phosgene	CG	In light concen.—Cut corn. In heavy concen.—Ensilage.	Thin white cloud produced; coughing; tightness in chest; eye irritation.
Chlorpicrin	PS	Sweetish, like licorice	Lacrimation; vomiting.
Chloracetophenone.	CN	Locust or apple blossoms; ripe fruit.	Lacrimation; irritation of skin in hot weather.
Tear Gas Solution**.	CNS	Sweetish	Lacrimation; irritation of skin.
Brombenzylcyanide**.	CA	Like sour fruit	Eye irritation usual before odor is noted. Eye irritation lasts some time.
Adamsite	DM	Odor from burning smokeless powder.	Canary yellow smoke haze; headache; vomiting.

*The cloud of vapor is invisible unless its color is noted in this column. Intensity of all odors increases with the concentration.

**Gases marked with double star are not included in the sniff set.

37. Use of Gas Samples.

Small samples of actual war gases can be used for training in gas identification. The following rules apply:

a. Memorize the odors and associate them with the gas.

b. Before starting the test, take a deep breath of uncontaminated air. Exhale a portion.

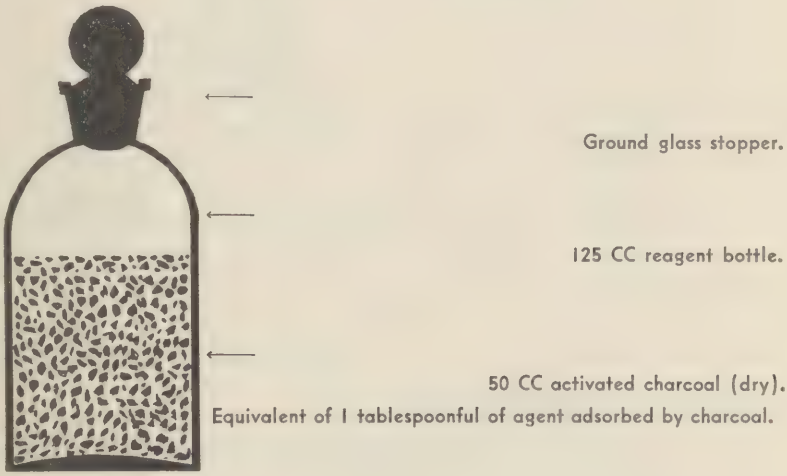
c. Sniff once and attempt to associate the odor with one of the known war gases.

d. Exhale and clear the nasal passages of the gas.

e. Do not repeat the test for several minutes. Repeated testing for some gases such as mustard will dull the sense of smell and prevent accurate identification.

Caution: Smoking dulls the sense of smell. Do not smoke while learning the odor or at any time while testing for gas.

FIG. 13. Cross-section of bottle in sniff set.



38. The Sniff Set.

An important instructional aid for teaching odors is the use of a "Sniff Set." The one used for instruction by the Army consists of seven 4-ounce glass bottles, one of which is shown in figure 13. These bottles contain, respectively, mustard gas (2 bottles), Lewisite, Adamsite, chlorpicrin, phosgene, and the tear gas CN. The gas is

adsorbed by charcoal and is given off gradually when the stopper of the bottle is removed.

If the bottles are not used for a long time, sufficient pressure may be built up in them to throw out some of the contents when stoppers are first removed. Therefore, before using the set the bottles must be opened by someone wearing a mask. The bottles will then be safe for use for the next 24 hours. When not in use the bottles must be kept stoppered. It is important to replace the stoppers in the right bottles.

FIG. 14.

39. Use of Sniff Set.

It is important to use the set correctly. The following procedure should be employed:

a. Shake the bottle gently.

b. Remove the stopper carefully.

c. Pass the stopper under the nose and sniff gently. If the odor is too faint to recognize, hold the stopper under the nose for a few seconds.

d. If this fails, pass the mouth of the bottle under the nose and sniff *gently,* but *do not hold it there.*

SECTION 5—FIRST AID TREATMENT OF GAS CASUALTIES

40. General Considerations.

The Army gas mask is the best individual protection against chemical warfare agents. *It will not, however, protect against carbon monoxide, ammonia, or oxygen deficient atmospheres* and is, therefore, not suitable for use in fighting fires or in industrial accidents where ammonia fumes are present. It is important to learn by practice how to put on and adjust the mask quickly.

The amount of agent in the air (the concentration) determines the intensity and rapidity of the effects produced. The higher the concentration, the shorter is the period of exposure required to produce a casualty.

Get out of the contaminated atmosphere or area as soon as possible. Gases tend to travel downwind. If gas has been released in your immediate vicinity by bomb explosion or spray, move upwind. If gas has been released upwind from you, move across the wind till you are out of the stream.

Most agents are heavier than air and tend to settle in hollows. Therefore, avoid low places or basements. The second story of a building is practically safe. Close doors and windows, stuffing cracks and chimneys; this will keep gas out for hours. If windows are blown out by explosions, hang wet blankets over openings to keep gas from blowing in. The blankets should be fastened tight at the edges.

41. Lung Irritants.

Phosgene
Chlorpicrin
Chlorine
(Nitric fumes)

All chemical warfare agents may act as lung irritants under certain circumstances, but with phosgene, chlorpicrin, chlorine, and nitric fumes, lung irritation is the most conspicuous effect. Nitric fumes have not been used directly in an attack, but are one of the gaseous products of nitrate explosives. Rescue Squad workers and others required to enter poorly ventilated buildings or tunnels following explosions may be exposed to dangerous concentrations of nitric fumes.

a. LATENT PERIOD.

There is usually a latent period of 1 to 12 or more hours between exposure to lung irritant gases and development of symptoms. Cigarette smoke is unpleasant during this period, but there may be no other indication that an individual has been gassed. This latent period always occurs after exposure to phosgene and may be longer than 12 hours; after exposure to chlorine, there may be none. After chlorpicrin, the latent period is short and may be less than an hour; after nitric fumes, it is long like that of phosgene. Chlorpicrin may cause eye irritation and vomiting in addition to lung irritation.

Persons exposed to lung irritants must be kept quiet during the latent period when they feel perfectly well. Any activity may cause sudden collapse and death. Patients must lie quietly and not attempt to feed themselves or even sit up.

b. EFFECTS.

Lung irritants cause pulmonary edema, a water-logged condition of the lungs which may cause the victim literally to drown in his own body fluids which pour into the irritated lungs. It is difficult for the heart to force blood through the damaged lungs, and death may result from circulatory collapse (heart failure) if the patient does not "drown."

c. SYMPTOMS.

There may be none for 12 to 24 hours after exposure, except that cigarette smoke is unpleasant. Examination of the chest by a physician reveals nothing abnormal. The patient then begins to breathe rapidly, becomes flushed and then bluish, and may develop a painful cough with swelling of neck veins (Blue Stage). He may cough up blood-tinged frothy sputum and appear to be strangling. He may develop circulatory failure and turn a greyish leaden color, become cold and clammy, as in shock (Grey Stage). After recovery from this, he is still in danger of developing bronchopneumonia.

d. FIRST AID.

(1) Remove from the gaseous atmosphere and keep patient absolutely quiet in bed or on a stretcher. He must under no circumstances walk or even sit up, even though he may feel perfectly well. Keep him warm with blankets and hot drinks, and get him to a doctor as soon as possible.

(2) Do not give artificial respiration to relieve difficult breathing in the blue or grey stages. The lungs are full of water and any additional manipulation may be fatal.

(3) If symptoms appear, the patient should be given oxygen to breathe if available.

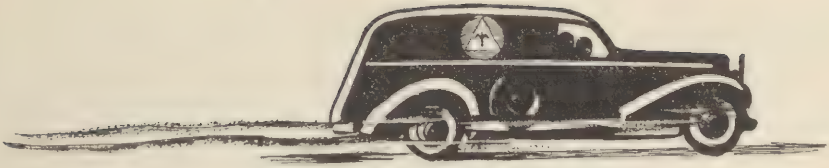


FIG. 15. Gas casualties should be hospitalized as soon as possible.

42. Blister Gases.

Mustard
Lewisite
Ethyldichlorarsine

These agents, either as liquid or as vapor irritate, burn and blister any skin or mucous membrane with which they come in contact. Because of their persistence and insidiousness, blister agents cause many casualties, but the death rates are low. Only 2 percent of blister agent casualties in the World War were fatal.

a. SPECIAL CHARACTERISTICS.

(1) *Persistence.*—Under normal weather conditions in temperate climates, they may persist for days in an area sheltered from wind and sunlight. In winter they persist longer.

(2) *Power.*—The power of these agents is so great that a drop the size of a pinhead can produce a blister the size of a quarter. Exposure for 1 hour to air containing one part per million of vapor can cause a casualty. The eyes are particularly susceptible.

(3) *Penetration of materials and of the human body.*—The blister agents "soak in" as ink soaks into a blotter. This is not the same as "eating in" as of an acid; the penetration takes place without damage to clothing. Because the agents are highly soluble in fats, they also readily soak into the body. A drop of mustard on the skin

FIG. 16. Mustard Gas blister.

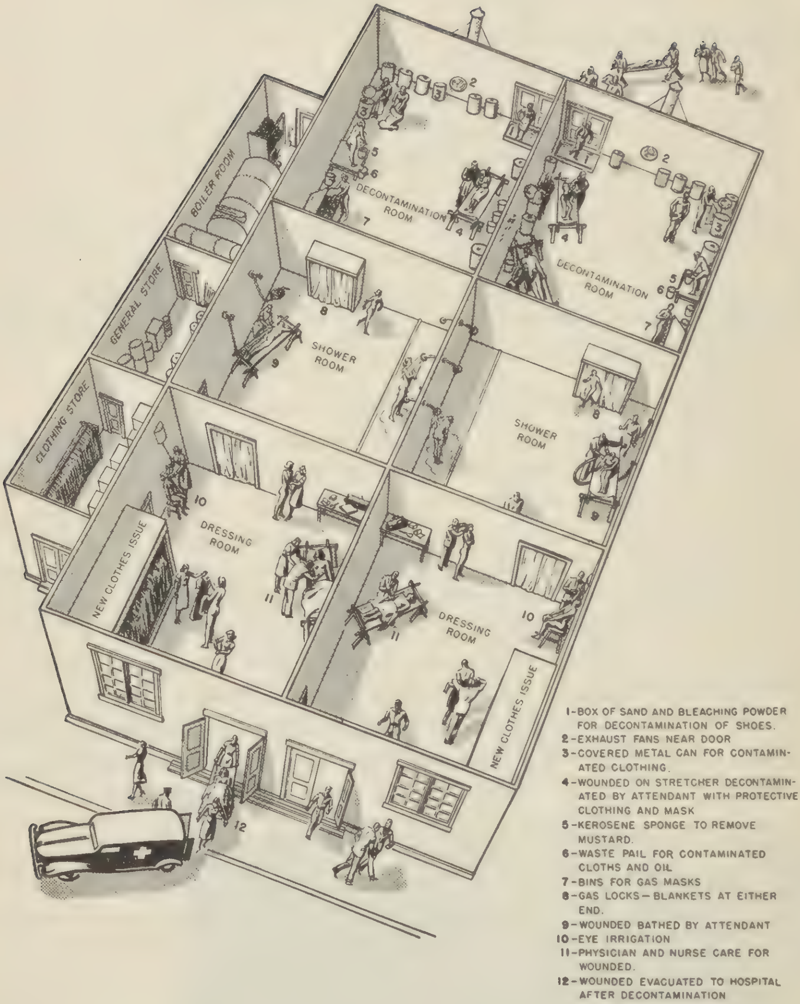


FIG. 17. Gas decontamination station.

glistens for about two minutes and then is adsorbed. Only metals, glass, highly glazed tiles and porcelains, and specially treated fabrics resist their penetration. The agents penetrate rubber.

(4) *Insidiousness.*—Even in concentrations sufficient to cause burns, the presence of these agents, particularly mustard, may not be detected by odor or by any immediate irritation.

(5) *Delayed action.*—Their ability to cause damage before any evidence of their presence is recognizable makes these agents dangerous. A patient may be sufficiently contaminated to cause extensive burns and show no signs of injury for 12 or more hours.

(6) *Universal action.*—The effects of these agents are not limited largely to one set of body structures as is the case with tear gases and lung irritants. They burn and blister any tissue with which they come in contact, whether it be on the surface or in the interior of the body. The lungs may be injured by breathing vapor; the stomach may be injured by swallowing contaminated food, water, or even saliva.

There are two types of blister agents:

(1) Those which cause only local surface irritation.

(2) Those which also cause systemic (internal) poisoning. These usually contain arsenic.

More than any other type of chemical agent, the blister gases, especially those containing arsenic, will poison food and water, and render other supplies dangerous to handle until they have been decontaminated.

Before transporting or treating blister agent casualties, medical unit personnel must apply to themselves those individual or collective measures which are necessary for their own protection, or they will also become casualties. A gas mask protects only the face, eyes and lungs; protective ointment must be used on exposed parts and protective clothing worn where possible.

It is important to distinguish between mustard and Lewisite burns because of the greater severity and danger of arsenic poisoning from Lewisite.

The effects of this group of chemicals vary with the portion of the body exposed. Signs and symptoms may be delayed, particularly with mustard. The length of the latent period depends on the concentration of the agent and on the individual sensitivity of the skin. *Prolonged exposure to concentrations barely detectable by odor will produce casualties.*

b. MUSTARD.

(1) *Effects.*—In persons unprotected by masks, eye symptoms are generally the first to appear. These begin with smarting and water-

Table 2.—Differences Between Lewisite and Mustard *

[Lewisite is more volatile at low temperatures than mustard and is therefore more dangerous in cold weather]

	MUSTARD	LEWISITE
Immediate effects:		
On skin	None, even from liquid	Sharp tingling from liquid.
Nose	None	Breathing vapor for few minutes causes sharp burning irritation.
Eyes	None from vapor. Mild irritation from liquid.	Immediate severe pain from liquid.
Skin burns	Much itching; little pain. Blisters filled with clear fluid and surrounded by an area of erythema (redness).	Painful as well as itching; blisters filled with cloudy fluid. No surrounding erythema (redness).
Late effects:		
Skin	Burns only skin	Burns through skin into muscles.
Eyes	Severe inflammation but rarely scarring with loss of vision.	Inflammation more severe and usually causes some scarring and permanent impairment of vision.
Entire body	Produces no systemic (internal) poisoning.	Produces systemic poisoning with arsenic.

* Prolonged exposure to either mustard or lewisite in concentration barely detectable by odor will cause casualties.

ing of the eyes 2 or 3 hours after exposure to vapor, followed by reddening and swelling. There is considerable pain, especially from bright light, and swelling may completely close the lids. If liquid is splashed into the eyes, there is almost immediate burning and all symptoms develop more rapidly. Eye burns vary from simple irritation and redness following mild vapor to severe ulceration from liquid mustard.

Sneezing and running nose are also early symptoms.

Skin burns from vapor may not appear until 12 or more hours have elapsed, but may develop within 1 hour after contact with liquid mustard. The first symptom may be severe itching, followed by a sunburnlike redness, upon which small and large blisters develop. Shortly before the development of blisters, the surface of the reddened skin can be rubbed raw with slight pressure and friction. When liquid has been splashed on the skin, the blisters may be arranged in a ring around a central, whitish, indurated area. The blisters are surrounded by a zone of redness. Because of the depth of skin destruction, mustard burns may require some weeks to heal and may become infected.

Vapor burns are more severe on areas of the body covered by clothing, which interferes with the dissipation of the mustard, and also on those areas subject to friction where the skin is moist or thin. The elbow, knee and neck folds, external genitalia, and armpits are particularly susceptible. The fluid contents of mustard blisters are not irritating to the skin.

Irritation of the lungs is first indicated by hoarseness followed by a harsh brassy cough, later followed by production of yellowish sputum. These cases are serious because bronchopneumonia may develop. This condition was responsible for most of the deaths from mustard gas during the World War.

Stomach irritation with nausea and vomiting may result from swallowing contaminated food, water, or even saliva.

(2) *Prevention—First Aid.*—To be effective, treatment must begin within a few minutes after exposure. *Immediate prophylaxis is effective only up to 5 minutes after liquid contamination.* It is of little value after exposure to vapor because, in this form, most of the agent has penetrated the skin before the person reports for treatment.

Contaminated clothing must be removed quickly, using proper precautions (mask, gas proof gloves, apron, protective ointment) to protect the attendant. Clothes must be placed in a covered metal container until decontaminated.

Great care must be used in the removal of mustard from the skin; otherwise the agent will merely be spread. The steps are as follows:

(*a*) Gently apply dry pads to absorb any mustard remaining on the skin.

(*b*) Gently and repeatedly dab the area with sponges dampened with gasoline (nonleaded), kerosene, carbon tetrachloride, or alcohol. These solvents, except carbon tetrachloride, are inflammable; keep away from open flame. Have sponges only damp with solvent; if dripping wet, they may dissolve and spread the agent as they run over the skin.

FIG. 18.

(*c*) Scrub the skin surface within and beyond the margins of the contaminated area with soap and water.

(*d*) Pat the area dry with a towel. *Do not rub.*

(*e*) Burn or bury the materials contaminated during the procedure. Keep away from the smoke while contaminated materials are burning. It may contain mustard vapor.

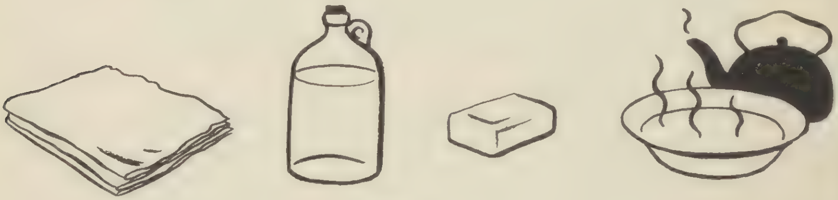


FIG. 19.

A protective ointment developed by the U. S. Army also effectively removes mustard from the skin surface if it is applied with rubbing and then wiped off. Products containing active chlorine, such as bleaching powder and commercial bleaching solutions, may also be used. Bleaching powder should be mixed with one or two parts of water. Dry bleaching powder may be used if water is not available, but the reaction with mustard will generate some heat. Even so, the effect will be less than if mustard were left on the skin. Ordinary bleaching powder does not exceed 30 percent chlorine; high-test bleaching powder of 70 percent chlorine should never be used dry.

Bleaching powder and solutions are irritating and must be removed from the skin as soon as possible (within a few minutes) or they will increase the burn. *Be sure to keep them out of the eyes.* If reddening of the skin indicates that the burn has already begun to develop, *do not use these compounds; they will only increase the irritation.* It is preferable to apply anti-pruritic ointment (par. 48, item 10) to relieve the itching.

The eyes should be irrigated with a 2-percent solution of sodium bicarbonate (baking soda) unless they have been protected by a mask. The solution should be run directly into the eyes with a rubber tube from an enema can or similar container. Petrolatum on the edges of the eyelids will prevent their sticking together. A 2-percent solution of butyn may be instilled in the eyes to relieve pain. *Cocaine must not be used;* it may cause ulceration. *The eyes must not be bandaged.*

FIG. 20.

FIG. 21.

If it is likely that mustard has entered the mouth or nose, the mouth and nasal passages should be rinsed and the throat gargled repeatedly with 2-percent solution of sodium bicarbonate. The patient should be kept quiet and warm to guard against bronchitis and bronchopneumonia.

If nausea and vomiting indicate that contaminated materials have been swallowed, the stomach should be washed out by repeated drinking of warm 2-percent solution of sodium bicarbonate. This will induce vomiting and wash out the irritant.

After decontamination, all persons with eye, nose, and throat burns and with extensive skin burns should be hospitalized. Skin burns must be treated surgically as any severe extensive burn.

c. LEWISITE.

Lewisite is similar to mustard in physical characteristics, but it is more volatile and hence more effective in cold weather. It is also more immediately irritating and is more dangerous because it contains arsenic. Water breaks it down into a solid oxide containing arsenic, which is also irritating and poisonous. This solid is extremely persistent; contact with ground contaminated with lewisite will cause burns for a long time afterward.

(1) *Early effects.*—Symptoms develop earlier and are more severe than with mustard. Liquid lewisite in the eye causes immediate pain. On the skin, redness appears within 15 to 30 minutes after contamination with liquid, and blisters soon appear, reaching their maximum within 12 hours. The entire area blisters, leaving no red

margin around the blister as is usually observed in mustard burns. *The blister fluid contains arsenic and is itself capable of causing burns and general poisoning.*

(2) *Late effects.*—Lewisite burns are more painful and more dangerous than mustard burns. Lewisite in the eye may cause loss of vision. In addition to painful burns which may later become infected, symptoms of arsenic poisoning may appear. These are dryness and soreness of the throat, diarrhea, and restlessness. Later, paralysis may develop.

Until neutralized or removed, lewisite continues to penetrate, burning through the skin into muscle or other body tissue. It differs in this respect from mustard, which never penetrates beneath the skin unless carried into a wound by contaminated shell or bomb fragments.

(3) *Prevention—First aid.*—(*a*) *Eyes.*—Liquid lewisite in the eyes is an emergency. The eyes must be rinsed immediately with 2 percent hydrogen peroxide. If that is not available, they must be irrigated with 2 percent solution of sodium bicarbonate. Delay may result in blindness.

(*b*) *Skin.*—*Treatment must begin within 1 minute* after exposure to liquid lewisite to be really effective. Contaminated clothing must be quickly removed with precautions to protect the attendant, and treatment should be started while clothing is being removed.

The contaminated areas should be swabbed immediately and repeatedly with hydrogen peroxide. Solutions with 10 or even 20 percent available oxygen are best but are somewhat unstable. The ordinary 2-percent solution available in drug stores will suffice. If hydrogen peroxide is not available, a solution of 10 percent sodium hydroxide (lye) in a 30-percent solution of glycerin in water, alternating with 70 percent alcohol, is the second choice. The glycerin protects the skin from the lye. If no glycerin is available, 5 percent lye in water may be used. Lacking all these, the solvents and technique described for liquid mustard must be used. Following treatment, the skin should be washed with soap and water and patted dry. *All contaminated cloths or sponges must be burned or buried.*

It is extremely urgent that patients contaminated with lewisite come immediately under medical treatment. The doctor must open the blisters as soon as possible to prevent further absorption of arsenic. In opening the blisters, he must be careful to prevent infection and must remember that the blister fluid itself is capable of producing burns. If liquid lewisite has remained on the skin for any considerable length of time, surgical removal of the contaminated

area may be necessary to reduce the risk from the arsenic which it contains.

d. ETHYLDICHLORARSINE.

(1) *Immediate effects.*—It is more irritating to nose and throat than lewisite or mustard. Immediate symptoms of sneezing and often vomiting are therefore common. It is less irritating to the skin and therefore less apt to blister. It is capable, however, of causing arsenic poisoning.

(2) *First aid.*—Immediate measures are the same as for lewisite. Nose irritation may be relieved by inhaling dilute chlorine from a small amount of bleaching powder in a wide-mouthed bottle or can. Repeated drinking of warm 2 percent sodium bicarbonate solution should be used for vomiting.

43. The Irritant Smokes (Sneeze Gases or Sternutators).

Adamsite
Diphenylchlorarsine

These agents are used to produce irritation of the nose, throat, and eyes, and are dispersed in clouds or smokes of very fine particles rather than as true gases. Their action is so delayed that symptoms may not appear until after the mask has been put on. When this occurs, an untrained person may think his mask unsatisfactory and remove it, becoming a casualty from further exposure. These agents are very insidious. They have no odor and are usually detected only when symptoms appear.

a. EFFECTS.

There is pain and a feeling of fullness in the nose and sinuses accompanied by violent sneezing and running of the nose. Severe headache may develop, followed by burning in the throat and tightness and pain in the chest. Nausea and vomiting may occur, and eye irritation may produce a flow of tears. A striking peculiarity of these agents is the mental depression they may induce. Severely gassed persons may attempt suicide.

b. DIAGNOSIS.

This is based on the presence of the symptoms just described, followed by relatively rapid recovery despite the miserable appearance and condition of the individual.

c. FIRST AID.

Remove to pure air if possible. A nasal spray of pontocain and neosynephrin gives relief (par. 48, item 12). Inhalation of dilute

FIG. 22.

chlorine from a small amount of bleaching powder in a wide-mouthed bottle or can is also effective. Headache may be controlled with 10 to 15 grains of acetylsalicylic acid (aspirin). There are no after effects and the individual recovers within a few hours.

Severely exposed individuals must be watched for suicidal tendencies. Continue to reassure them that their symptoms will be of brief duration and are not dangerous.

44. *Tear Gases (Lacrimators).*

Chloracetophenone
Chloracetophenone Solution
CNB solution
Brombenzylcyanide

a. EFFECTS.

Exposure immediately produces spasm of the eyelids with sensitiveness to light, inability to open the eyes, copious tears, and some irritation of a freshly shaven face. Chloracetophenone solutions may cause a mild rash in warm weather and ocassionally vomiting. If the solution itself gets into the eyes, there may be permanent damage.

b. FIRST AID.

The individual should be removed from the contaminated air and face the wind with eyes open. If irritation is marked, the eyes may be irrigated with boric acid or a 2-percent solution of sodium bicarbonate (baking soda). *The eyes must not be rubbed or bandaged.*

Skin irritation may be treated by sponging with a solution of 4 percent sodium sulfite in 50 percent alcohol. All symptoms usually disappear within an hour.

45. *Incendiaries.*

Thermit—molten or burning metal
Oil
White phosphorus

a. THERMIT AND OIL.

Burns from molten metal are apt to be deep and severe due to the

high temperature. Immediate first aid consists in flushing spattered globules of metal with large quantities of water to produce cooling. Flaming oil on clothing or skin must be smothered. Cases are then treated as burns from any other cause.

b. WHITE PHOSPHORUS.

This agent ignites by itself in the air. Water or wet cloths will quench the fire, but as soon as the particle dries in air, it again begins to burn. The effect of particles on the skin is the same as of any heat burn; they stick and burn until removed, or until air is excluded by covering with water or treating with copper sulphate.

First aid.—Keep the burn wet with water or wet cloths until the particles can be squeezed or picked out. Warm water, about 40° C. (104° F.) melts phosphorus and makes squeezing easier. If squeezing does not bring out the particles, they must be picked out with forceps. Do not use mud as formerly recommended; it may cause infection. Urine is sterile and is satisfactory if there is no other source of water.

Unless there is water and time for immediate treatment, apply a 5 to 15-percent solution of copper sulphate to the burn. This coats the phosphorus with copper phosphide, shuts out the air and stops the burning until the particles can be removed.

After the phosphorus has been removed, further treatment is exactly the same as for any other heat burn.

46. The Screening Smokes.

White phosphorus
Titanium tetrachloride
Sulphur trioxide—chlorsulfonic acid solution
HC mixture

a. WHITE PHOSPHORUS.

The smoke from white phosphorus is harmless, but particles from a shell explosion will cause burns and should be treated as described under incendiaries.

b. TITANIUM TETRACHLORIDE AND SULPHUR TRIOXIDE-SOLUTIONS.

The liquids produce acid-like burns of the skin. They are irritating and unpleasant to breathe, but are not dangerous. Spray in the eyes may cause serious burns.

First aid.—This consists in washing with large quantities of water. In the eyes, this should be followed by irrigation with a 2-percent solution of sodium bicarbonate (baking soda). If severe, the patient must see a physician.

47. The Systemic Poisons.

Hydrocyanic acid
Arsine
Hydrogen sulfide
Carbon monoxide

Although not immediately irritating to the skin, eyes, nose, or lungs, these agents cause systemic (internal) poisoning, and if inhaled in sufficient quantity, they may cause death. Hydrocyanic acid and hydrogen sulfide may be immediately fatal; arsine produces destruction of the red blood cells which block the kidneys and may cause death in a few days. Carbon monoxide, while not used as a war gas, may be encountered following breaks in illuminating gas mains.

a. HYDROCYANIC ACID AND HYDROGEN SULFIDE.

(1) *Immediate effects.*—Odor of bitter almonds (hydrocyanic acid), or rotten eggs (hydrogen sulfide) may be noticed, but strong concentrations dull the sense of smell and the individual may be overpowered and collapse immediately. Weaker concentrations may produce headache, dizziness, and nausea.

(2) *First aid.*—Anyone rendering first aid in a gassed area to an individual who has just collapsed must be protected by a mask or he will also collapse. *Do not enter a gassed area without a mask to bring anyone out; you will not get out yourself.*

First aid consists in inhalation of amyl nitrite fumes and artificial respiration, until a physician can begin medical treatment. Artificial respiration should be continued for hours, even though it appears hopeless.

b. ARSINE.

Odor of garlic and metallic taste are the only immediate effects. Persons exposed to arsine must be kept quiet and hospitalized as soon as possible. Meanwhile, they should be given large quantities of alkalies such as sodium bicarbonate, citrate or phosphate to drink. This alkalinizes the urine and may help to prevent coagulation in the kidneys of protein from the red blood cells destroyed by the arsine.

c. CARBON MONOXIDE.

This is the colorless, odorless constituent of automobile exhaust and artificial illuminating gases which causes many fatalities. It replaces the oxygen in the blood and the victim is rapidly asphyxiated. It may be encountered in enclosures where fire has been burning with a limited air supply, in basements and tunnels where gas mains have been ruptured, and in other closed places.

(1) *Effects.*—With high concentrations, the victim collapses

without warning after breathing the contaminated atmosphere for a few minutes. Lower concentrations first cause headache and dizziness, followed by collapse.

(2) *First aid.* Immediate removal from the contaminated atmosphere is most important. If breathing is shallow or has stopped, artificial respiration must be instituted and continued till the patient is breathing normally again. This may require some hours.

As soon as it can be made available, the individual should be given oxygen to breathe. Do not wait for oxygen before starting artificial respiration.

48. Recommended Contents of Special First Aid Chest for Gas Casualties.

1. Bleaching powder—High test .... 2 pound.
   For decontamination of skin from blister agents; for inhalation following irritant smokes.
2. Protective ointment—3-ounce tube .... 10.
   For protection of skin and decontamination following blister agents.
3. Hydrogen peroxide—10 percent available oxygen .... 1 quart.
   For removing lewisite from skin.
4. Kerosene .... 6 quarts.
   For removing mustard from skin.
5. Alcohol—70 percent .... 1 quart.
   Following No. 4 and No. 8.
6. Soap .... 6 cakes.
   To remove No. 3, No. 4, and No. 8.
7. Sodium bicarbonate (baking soda) .... 5 pounds.
   A. For eye irrigation following blister gases, tear gas, or other chemical agents.
   B. For washing nose, throat, and stomach following blister agents.
   C. For drinking after arsine exposure.
8. Lye .... 1 pound.
   For lewisite if No. 1 and No. 3 not available.
9. Butyn. N. N. R. 3 gr. hypo. tablets, 10 tablets per vial .... 2.
   For preparing solution to relieve pain in eyes from mustard and lewisite.

10. Antipruritic ointment for mustard burns — 3 ounces.

	Percent
Benzyl alcohol	50
Stearic acid	30
Glycerine	10
Ethyl alcohol	8
Pontocaine	1
Menthol	1

To relieve itching following mustard burns.

11. 4 percent solution sodium sulfite in 50 percent alcohol — 8 ounces.

For removing tear gases from skin.

12. Neosynephrine hydrochloride 1 percent, 4
Pontocaine hydrochloride
Boric acid saturated solution 12 — 04-2 ounces.

For nose spray following irritant smokes.

13. Acid, acetylsalicylic (aspirin) 5-grain tablets — 100.

For headache following irritant smokes.

14. Cupric sulphate (blue vitriol) — 1 pound.

For phosphorus burns.

15. Amyl nitrate U. S.
Ampules—5 min. — 2 dozen.

For hydrocyanic-acid poisoning.

16. Absorbent cotton — 1 pound.

17. Enema can and tube for irrigating eyes — 1.

CHAPTER IV. COLLECTIVE PROTECTION.

SECTION 1. SCOPE.

49. Definition.

Collective protection consists of measures for the protection of a number of persons as a group. Such measures involve the provision of special equipment for a variety of protective activities, namely, the construction and operation of gasproof shelters, gas alarms and gas alarm systems, decontamination equipment and procedure, and measures for the protection of food and water. These subjects are dealt with separately in the following sections.

SECTION 2. GAS ALARMS.

50. Purpose.

A gas alarm is a device to give warning of a gas attack. The usual form of such warning is a distinctive sound, sufficiently loud to be heard readily throughout the area to which the alarm applies. In the case of a large city, a number of such alarms might be necessary and, in addition, it probably would be desirable to supplement these means by local alarms serving small sections. For the latter purposes, church bells, horns of the Klaxon type, or rattles, might be used.

FIG. 23.

51. Procedure.

In case of the bombardment of a city, it is impossible for the inhabitants to tell before the attack is actually launched whether the enemy will use gas, high explosive, or incendiary bombs, or all three of

these means. Consequently, the best procedure is to regard any warning of attack as a potential gas attack and act accordingly.

If gas is used on a large city, it may well happen that the entire city is not affected, but only one or more sections. In such a case, while everyone should be on the alert, people in areas some distance from those which are gassed may not have to adjust gas masks or seek refuge in gas shelters. The alarm system, however, should be such that people in each section of the city may be given warning in proper time in case their section is attacked directly or is endangered by gas drifting or being blown from another part of the city.

This necessitates a highly coordinated alarm organization, including gas detection personnel, making use of telephone and other means of rapid communication. As soon as the alarm pertaining to any portion or section of the city is sounded, or the presence of gas is detected, all persons in the affected area adjust gas masks, leave the streets and seek refuge in shelters.

SECTION 3. GASPROOF SHELTERS.

52. Definition.

A gasproof shelter is an enclosure sealed to prevent entrance of contaminated air or provided with equipment to remove gases from entering air. It is not necessary for the occupants to wear gas masks in such a shelter. If a gas attack upon a community is prolonged or if a persistent gas is used, such shelters are required for eating, sleeping and rest.

Gasproof shelters are also desirable for carrying on such important activities as medical aid stations, hospital operating rooms and telephone exchanges, in which the use of gas masks would be a decided encumbrance. Gasproof shelters are of two general types, nonventilated and ventilated.

a. Nonventilated shelter.—This is merely a room, building, cellar, cave, or other enclosure, sealed so as to prevent air from the outside from entering. Such shelters can only be occupied for a limited time since the air within them becomes foul after continued occupancy. The time during which such a shelter can be used depends upon its size and the number of persons occupying it.

b. Ventilated shelter.—This is an enclosure rendered reasonably gastight, and equipped with apparatus to draw in outside air through a canister which removes gas. Such shelters can be occupied indefinitely.

FIG. 24. Air-lock doorway leading down to shelter opening at each end is covered with blanket.

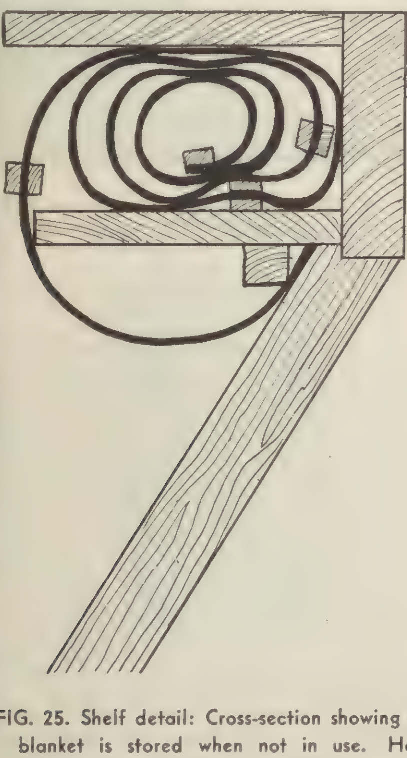


FIG. 25. Shelf detail: Cross-section showing how blanket is stored when not in use. Heavy black line represents edge of blanket.

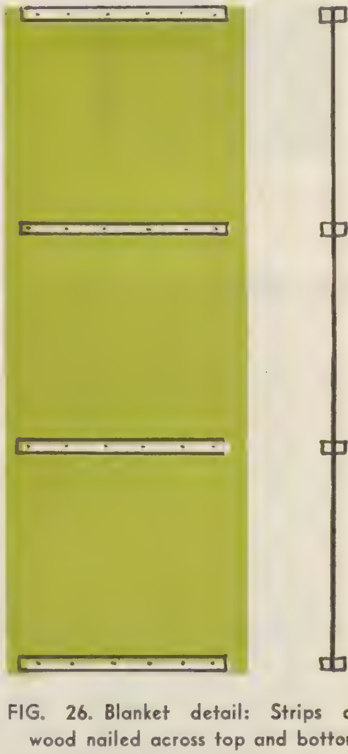


FIG. 26. Blanket detail: Strips of wood nailed across top and bottom of blanket and at points between; top of blanket nailed to doorframe. Side view at extreme right.

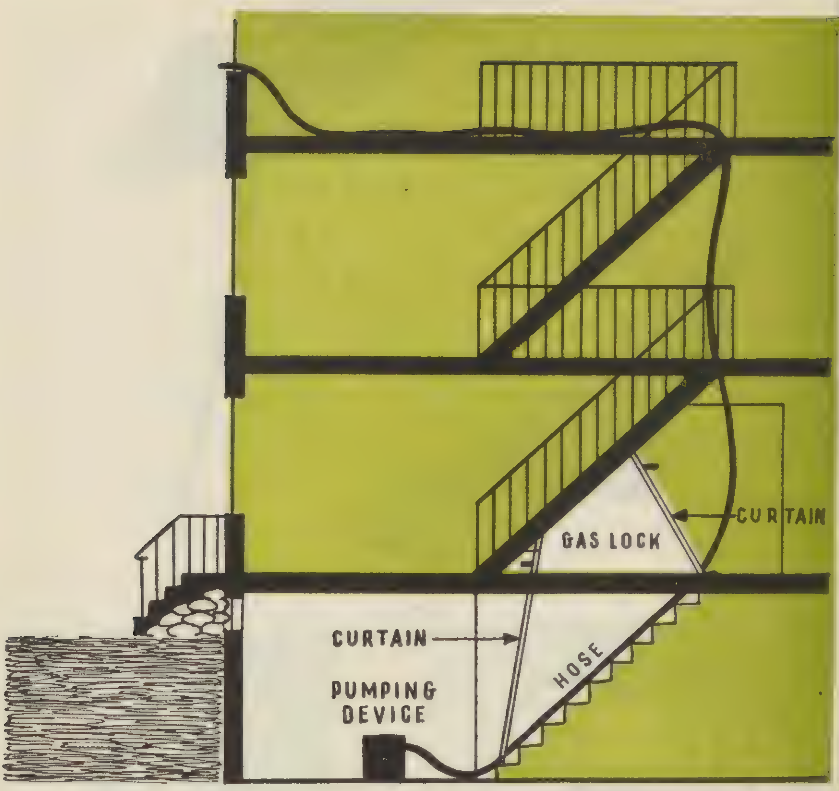


FIG. 27. Air may be pumped down from upper levels to a basement shelter, provided double gas curtains are used in entrance.

53. Relative Danger.

Assuming the inhabitants of a city are provided with gas masks and adequately trained, it is considered that the relative danger to life from the different forms of air attack is of the following order: (1) High explosive bombs; (2) incendiary bombs; (3) gas bombs. However, unless adequate gas protection is provided, the gas attack assumes first place in the order of relative danger. From this it is evident that, if one has a gas mask, his first consideration in seeking protection against air raids is shelter against high explosive bombs. In case gas is also used, he can rely on his gas mask for protection.

It is desirable, of course, that bombproof shelters also be made gasproof. This usually can be done without much additional expense or labor. The construction of bombproof air-raid shelters is dealt with in another manual. Hence only gas-proofing provisions are considered here.

54. Improvised Gasproof Home Shelters (Nonventilated Type).

A gasproof room in the home, to which the family together with the family pets can resort in case of a gas attack may be of service. However, it must be realized that the enemy is likely to use high explosives before the gas attack. The blast from the high explosives will probably shatter windows and otherwise interfere with the gas-proofing measures adopted in the home. Nevertheless, materials may be ready at hand to seal such a room as effectively as circumstances permit although too much reliance cannot be placed on its being entirely gasproof.

In the average home, the preferred location for such a shelter is the first floor or basement. Two exits should be provided. An air-lock doorway should lead into the shelter. A short passageway with the opening at each end covered by oil cloth or a blanket may serve as the air lock. Such an air lock prevents drafts of gas-laden air from being drawn into the enclosure as persons enter or leave the shelter.

To render the room reasonably gas-tight all openings should be closed. Oil cloth, coated fabrics, or other nonporous materials may be used to seal all openings. Transparent cellulose tape is useful for this purpose. Dampened blankets may be tacked over the window frames. Chimney openings should be sealed and all fires in the room must be extinguished.

FIG. 28. Blanket may be used to cover entrance to gasproof room. Fasten at top and sides with lath, leave sufficient length and bottom opening to pass through.

55. Nonventilated Shelters.

In erecting a structure that is specifically designed as an unventilated gas shelter, approximately 20 square feet of floor space should be allowed for each person to occupy the enclosure. Assuming the ceiling is of normal height, 8 to 10 feet, this will provide sufficient air for continuous occupancy of the shelter for about 10 hours. Thus a room 10 feet square will accommodate 5 persons, or one 20 by 12 feet will accommodate 12 persons.

Walls and ceiling must be constructed of concrete at least 12 inches thick, not lined with steel or waterproofed since this affects the absorption of carbon dioxide. Even with this provision it is estimated that at the end of ten hours a maximum of 2 percent of carbon dioxide (the allowable limit) may be reached if the shelter is occupied by adults averaging 160 pounds. If the walls are lined with steel or waterproofed on the inside, then the allowable limit of occupancy for such a shelter is five or six hours. Beyond this time, respiratory difficulties, headache, nausea, and even fainting may be caused by an excess of carbon dioxide.

The above figures are for shelters constructed in the temperate zone, where the ground temperature does not exceed 70° F. In warmer climates a larger floor space per occupant should be allowed.

When the foregoing recommendations for air space are adhered to, there will be ample wall-surface area for dissipation of body heat for the maintenance of tolerable temperatures, even in tightly sealed shelters, provided the wall surface area is uninsulated.

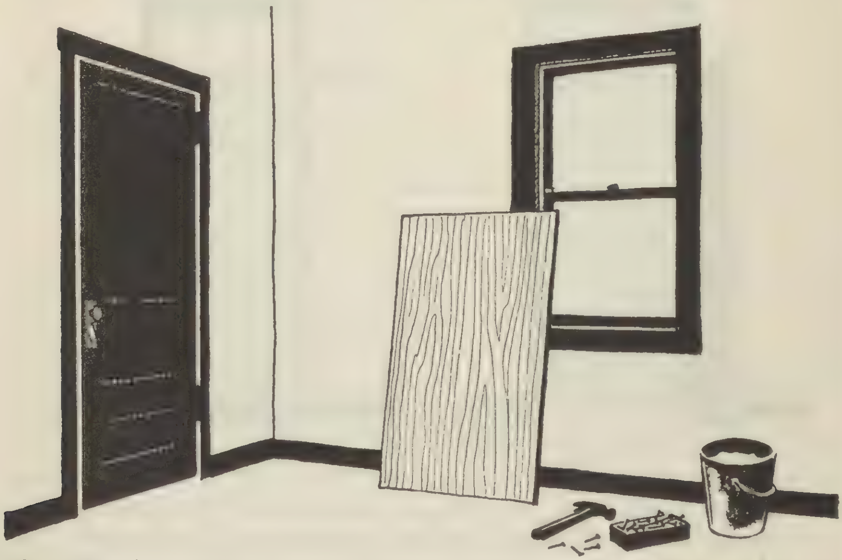


FIG. 29. Wooden covers for windows if properly caulked, prevent gas leaks and help stop glass splinters. Also useful as blackout screens.

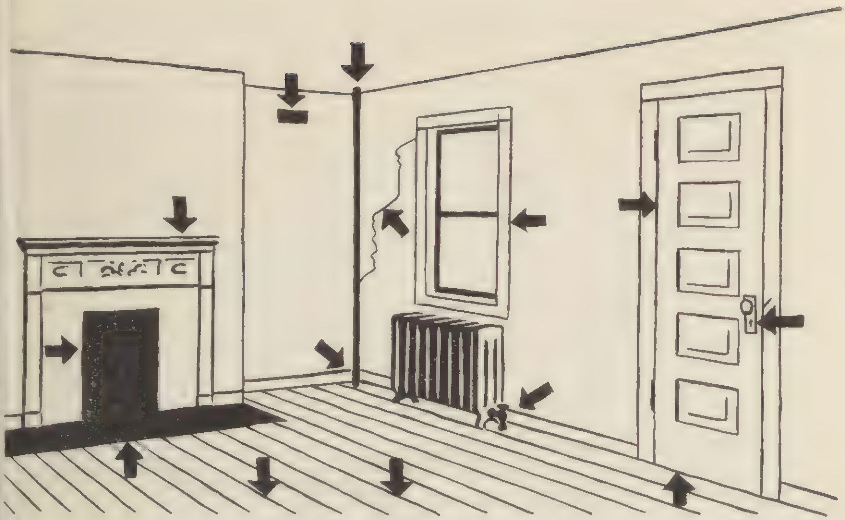


FIG. 30. All cracks and openings should be sealed to gasproof a room. Arrows show where to look for cracks and leaks.

Discomfort from continued occupancy of a shelter of this type is occasioned not only by lack of fresh air, but also by temperature and lack of air circulation. The use of an electric fan in the room is helpful. Also it is very desirable to place cotton bags filled with activated charcoal and soda lime in such shelters.

NOTE.— In underground shelters with all openings completely closed to guard against gas attack, the rise in air temperature will be 16° or 17° above the initial wall temperature in 8 hours, while in shelters above ground the rise in room temperature, under similar conditions but with 50 square feet of 12-inch concrete wall surface per person, will be approximately 10° during an 8-hour occupancy. However, where entrance doors may be left ajar, this rise in temperature, as well as the carbon dioxide concentration, will be greatly reduced.

56. *Ventilated Shelters.*

If a gas-proof shelter is to be occupied either for a greater length of time or if a smaller volume of air space is to be allowed per person than that specified in paragraph 55, then mechanical ventilation is necessary. In order that the carbon dioxide concentration shall never exceed the maximum allowable limit of 2 percent, it is necessary to supply 33 cubic feet of air per hour per person.

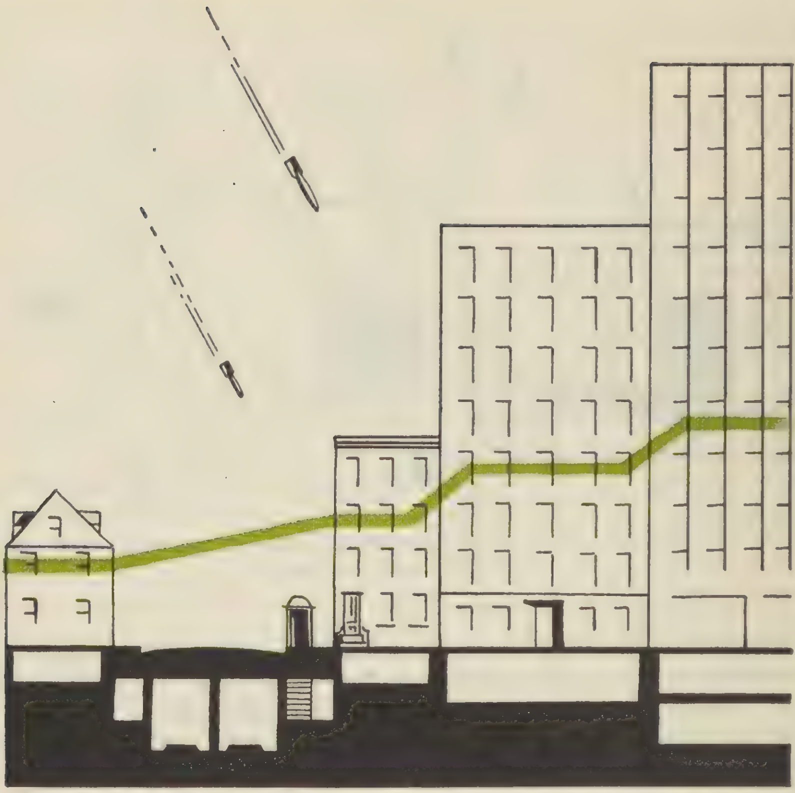


FIG. 31. Best height for protection against gas. Gas is denser near the ground; at upper floors it is greatly diffused. If there are three or four floors above, a room is protected from roof hits of explosivebombs.

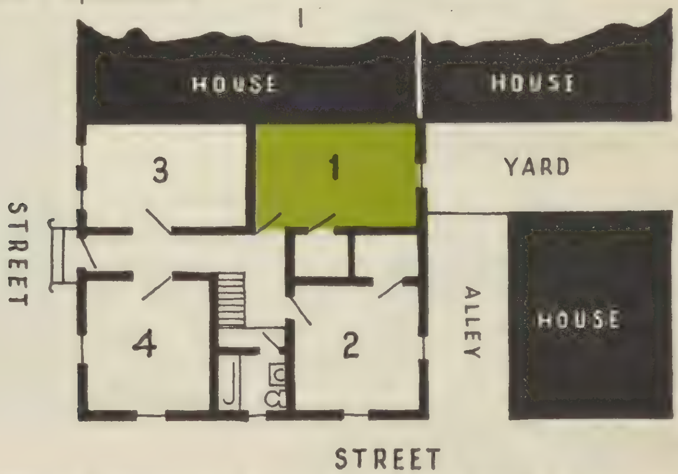


FIG. 32. Location of gastight room: Room 1 is best location because it has (a) one window and one door, (b) three protected sides, (c) fourth side partially protected from explosion wave by detached house. Order of choice of rooms is indicated by numbers.

The apparatus used to provide fresh air is called a "collective protector." It consists of a large canister or battery of canisters of virtually the same type construction as a gas mask canister, and a suction fan, operated either by hand power or a motor. By means of such an apparatus, fresh air is drawn into the enclosure, any gas or irritant smoke being filtered out or absorbed by the canister. It is desirable that the air intake be as high above the ground level as feasible and it is considered good practice to provide dual air intakes to guard against the possibility of one being choked by a nearby explosion.

The size and capacity of the collective protectors should be standardized and so designed that in an emergency they can be operated by hand by two people or by foot power by one person. This limits the power requirements per unit to about one-tenth horsepower.

NOTE.—Through such a unit with a resistance equal to approximately that of the weight of a 4-inch column of water, it is possible to draw approximately 80 cubic feet of air per minute with the expenditure of one-tenth horsepower. This will give a minimum air capacity of 1½ cubic feet per minute for 52 persons. A gage should be provided to indicate normal air flow. These units will normally be driven by power supplied by one-fourth horsepower motors. For shelters for more than 52 persons but less than 105 persons, 2 such units should be provided. For shelters for more than 104 persons but fewer than 157 persons, 3 such units should be provided.

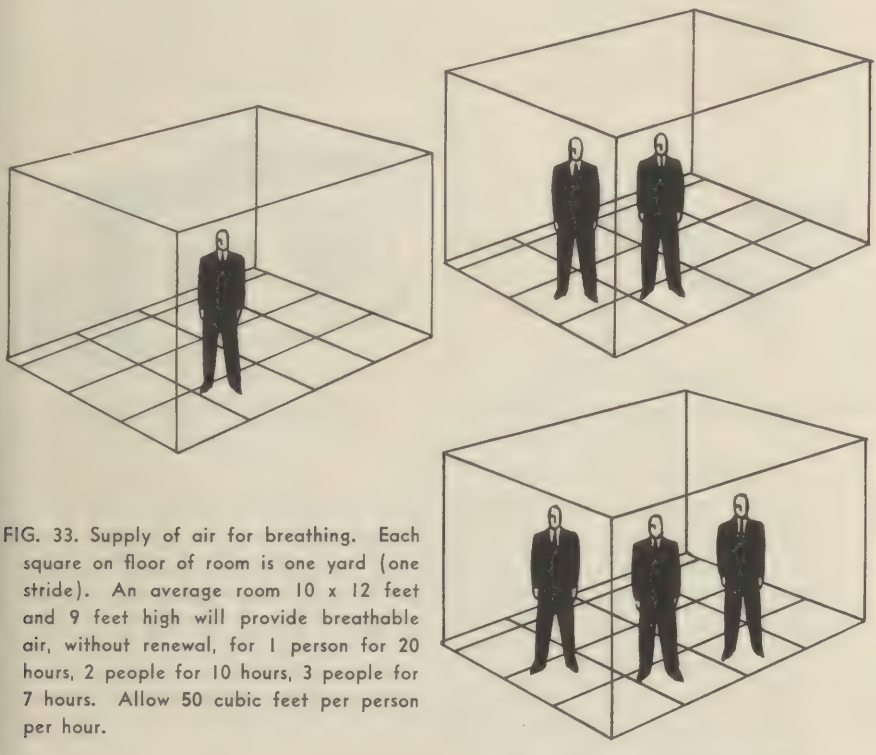


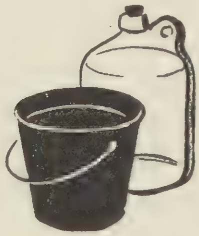
FIG. 33. Supply of air for breathing. Each square on floor of room is one yard (one stride). An average room 10 x 12 feet and 9 feet high will provide breathable air, without renewal, for 1 person for 20 hours, 2 people for 10 hours, 3 people for 7 hours. Allow 50 cubic feet per person per hour.

Hammer (claw type) and nails.

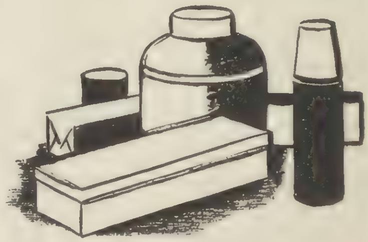
Caulking materials.

Scotch tape.

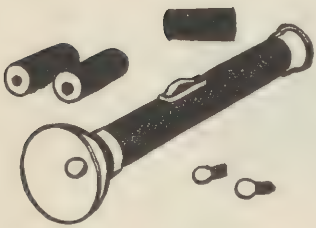
Toilet—Chemical type or simple container with tight cover.



Water for drinking, washing, soaking towels, and caulking.



Food in containers: Simple packaged foods, thermos bottles of coffee, milk, or other beverages.



Flashlight with extra bulbs and batteries.

Radio—Battery-operated if possible.

FIG. 34. Equipment for gastight room. If blister gases should be used in an attack, a gas refuge might have to be occupied for 6 or 8 hours. Supplies and equipment must be placed in the room in advance. There will be no time to collect them after the gas alert sounds. Since smoking quickly makes the air unbreathable, no smoking materials should be put in the room.

These units are intended to be operated by hand only as an emergency upon failure of power. It is the practice abroad to provide a bypass around the canister to give increased air quantity when not used in gas defense, but this practice is questionable for small units because of the danger of not having the bypass closed in case of gas attack.

For shelters housing more than 150 persons, it is recommended that an independent power plant be provided for driving a larger unit or units. Such a power plant will usually consist of a generator driven by a gasoline or propane motor. A battery and self-starter will presumably be provided for the motor. The ventilating units may then be of any size and driven by independent motors taking their power from the regular electric power lines of the city. In the event that fails, the motor-driven generator will supply current at the proper voltage for the ventilating units.

In severe weather sufficient heating capacity must be supplied in the air units to heat the air to about 60° F. In Europe it has been found undesirable to introduce air in crowded shelters at a lower temperature than 60° F. The incoming air is heated by an electric heater in the air circuit in the discharge side of the fan. The heated air should be discharged from a header with nozzles or holes which will cause intimate mixing by ejector action and thus prevent too great a difference between the exit air and the room temperature.

In underground shelters it is quite possible to provide cooling by means of uninsulated wall surface which has free access to natural air circulation within the room. To provide the maximum cooling area possible it is required that slatted wooden floors be provided, never solid wooden floors or matting.

The quantity of air supplied in ventilated shelters is insufficient to remove more than a fraction of the heat given off by the body and by lights. Unless artificial cooling is to be provided, the uninsulated wall surface area should be not less than 25 square feet per person in underground shelters, and not less than 50 square feet per person in above-ground shelters.

It is recommended that in the larger shelters having independent power plants that an air-cooled refrigerating machine be provided which will furnish cooling for a recirculating air-conditioning unit located within the enclosure. In such a case, the floor space can be reduced to 6 square feet per person either in the under-ground or the above-ground shelter. Such cooling systems must be of ample capacity to take care of approximately one-half of the total heat given off by the people in an under-ground shelter, or three-fourths of the heat in an above-ground shelter. This will require one-ton capacity of refrigeration for each 50 persons under ground or one ton for each 33 persons in an above-ground shelter where there is a minimum of

6 square feet available per person and the walls, floors, and ceiling are of uninsulated concrete. For example, above-ground shelters for 500 persons would require approximately 6.7 tons of refrigeration with air-cooled condenser.

57. *Air-Conditioning Equipment.*

Existing types of air-conditioning equipment present such variety of design and construction that no statement can be made as to the applicability of such equipment in connection with gas proofing. In each case, it is believed the services of a competent ventilating engineer should be obtained before any attempt is made to use such equipment.

SECTION 4. DECONTAMINATION.

58. *General.*

Decontamination is the process of neutralizing or destroying gas in areas which have been subjected to it. In general, no such measures are necessary following an attack with nonpersistent gas, since it quickly disappears through natural causes. However, if persistent gas is used, liquid contamination of streets and the exterior of buildings may result and, unless special measures are adopted, the chemical will remain a source of danger for some considerable time.

The chemical may have been sprayed on the city from airplanes or used in airplane bombs or artillery or mortar shells. Contamination also will result in the interior of any building in which such bombs or shell may fall. Upon the explosion of a mustard gas bomb or shell, part of the chemical will immediately pass off into the atmosphere as a gas. Part of it may be disseminated in the form of fine droplets floating in the air, while the remainder will be spattered about the bomb or shell crater. This, depending upon the size of the bomb or shell and the amount of the explosive charge, may be a considerable portion of the chemical filling of the munition used.

In addition to such liquid contamination, materials exposed to mustard gas vapor will absorb the gas and thus become contaminated. The best method of decontamination is to treat the affected area with another chemical which reacts with the gas, leaving a residue which is harmless or which can easily be washed away with water.

Decontamination work is arduous and dangerous. It requires trained personnel provided with gas masks and protective suits which cover the entire body.

59. *Decontamination Materials.*

a. General.—Materials used for decontamination are either chemicals which destroy chemical agents or which may be used to cover the contaminated area so as to prevent the escape of toxic gas therefrom, at least temporarily (fig. 26).

b. Bleaching powder.—The principal decontaminating agent for mustard gas is bleaching powder, otherwise known as chloride of lime. This material is a white powder, not very stable, which readily gives up its chlorine when exposed to the air or moisture. Chlorine reacts with mustard gas to destroy it, but must be brought into intimate contact with the gas.

Bleaching powder should be kept in air-tight containers until the moment of its use. Dry bleach should not be placed directly upon liquid mustard gas because the chemical process which takes place results in the evolution of heat and flame. This drives off a high concentration of mustard vapor which may be carried some distance by the wind, endangering people who would otherwise be safe. In using bleach on mustard gas, the bleach is either mixed with water as a paste or mixed with sand or earth.

The use of bleach is affected by the percentage of available chlorine, which varies between different types of bleach. Chloride of lime when freshly packed may have as high as 35 percent available chlorine. There are commercial compounds, under such names as H. T. H. and Perchloron, which contain as high as 70 percent available chlorine. There are also available commercial bleaching solutions which contain from 5 to 15 percent of available chlorine.

If using a compound which varies from the standard of 30 to 35 percent available chlorine, it is a safe rule to use 1 part of bleach, to 1 part of inert material for each 10 percent of available chlorine; thus, with 1 pound of 70 percent H. T. H. or Perchloron, 7 pounds of earth may be used; with 1 pound of 30 percent commercial chloride of lime, 3 pounds of earth may be used; or with 1 pound of 10 percent chloride, 1 pound of earth may be used.

c. Water.—Cold water has little, if any, effect on mustard gas except that, if applied with pressure, it will tend to drain the substance away. Hot water is fairly effective. Mustard gas is heavier than water and will lie at the bottom of pools and puddles, remaining effective for a long period of time, though the water over it will retard the escape of mustard vapor.

Water, either hot or cold, reacts quickly with Lewisite to destroy it. However, a solid residue is left which is dangerous to touch, though it gives off no gas. Even long after decontamination of a Lewisite area, it is dangerous to sit or lie down in the area. After

treatment with water, such an area therefore should be covered with a layer of earth, sand, or ashes. Articles contaminated with Lewisite which are to be handled should be treated with an alkali such as sodium hydroxide.

d. Earth.—Earth, sand, ashes, or sawdust may be spread over a contaminated area to give temporary protection. The covering should be at least 3 inches thick. This does not destroy the chemical agent. It forms a seal, preventing for a limited time the escape of toxic vapor. If practicable, the covering should be wetted down with water.

e. Sodium sulphide.—This chemical, prepared as a 1 percent solution with water, reacts somewhat more slowly than bleaching powder to destroy mustard gas. Since no heat is evolved in the process, mustard vapor is not driven off when it is used. The solution is more effective if heated. It may be used either as a spray, or mixed with sand in a proportion of one part (by weight) of the solution to four of sand. Six gallons of sodium sulphide solution are required for each square yard of area to be degassed.

f. Green solution.—This solution, which has a greenish color, is prepared by dissolving one pound of bicarbonate of soda (baking soda) in one gallon of commercial hypochlorite solution. This mixture is less efficient for destruction of mustard gas than bleaching powder but is also less corrosive to metals. It should be generously used with sponge or rag.

60. Decontamination Methods.

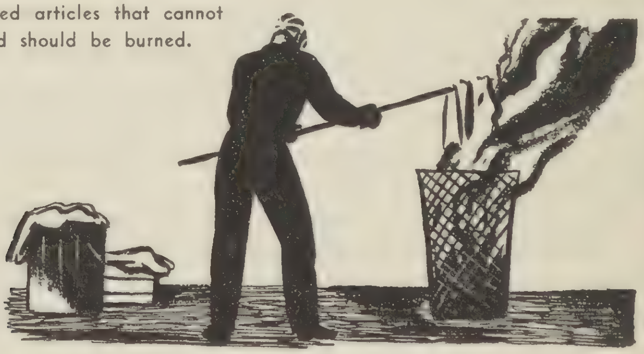
a. General.—Decontamination may be done by:

(1) Destroying the chemical agent by the use of other chemicals or by burning.

(2) Removing the chemical agent by washing it away.

(3) Covering the chemical agent with a seal, after which it will slowly be destroyed by the action of nature.

FIG. 35. Contaminated articles that cannot be decontaminated should be burned.



b. Burning.—Grossly contaminated articles which it is not practicable to decontaminate should be destroyed by burying them in the ground or by burning. In case such articles are burned, this should be done in the open or in an incinerator provided with a tall chimney in which there is good draft, since the burning process will drive off a high concentration of mustard-gas vapor.

Areas of land covered with dry grass and underbrush may be decontaminated by being burned over. Care in such cases should be taken to see that there are no persons down wind of the area within such distance as to be endangered by the gas cloud given off.

c. Application.—The application of these methods with respect to different types of materials is discussed below.

FIG. 36. Decontamination of ground.

(1) *Ground.*—Small areas of ground contaminated with mustard gas may be treated by spreading bleaching powder (mixed with sand or soil) over them and spading this mixture in the soil. Figures 27 and 28 illustrate simple decontamination procedure on roads and ground. About 1 pound of bleach is required per square yard of ground. The labor involved is considerable. If no bleach is available, the contaminated area should be covered with wet earth or sand.

FIG. 37. Decontamination of roads.

FIG. 38. After decontamination, wash away wastes.

(2) *Streets.*—Paved streets, lightly contaminated, may be rendered safe for use by washing them down with a heavy stream of water from a hose. Bleach paste or sand and bleach mixture should first be used on all heavily contaminated portions (fig. 27).

(3) *Walls and floors.*—The walls of buildings should be sprayed or scrubbed with a mixture of equal weights of bleach and water. Both wood and concrete absorb mustard. Therefore, a second decontamination may be necessary. After this treatment, the walls should be scrubbed with hot water, soap, and washing soda. Paint absorbs mustard gas.

Floors should be covered with a paste of bleach and water to a depth of 1 inch and left there from 6 to 24 hours. The paste should then be removed and the floor scrubbed.

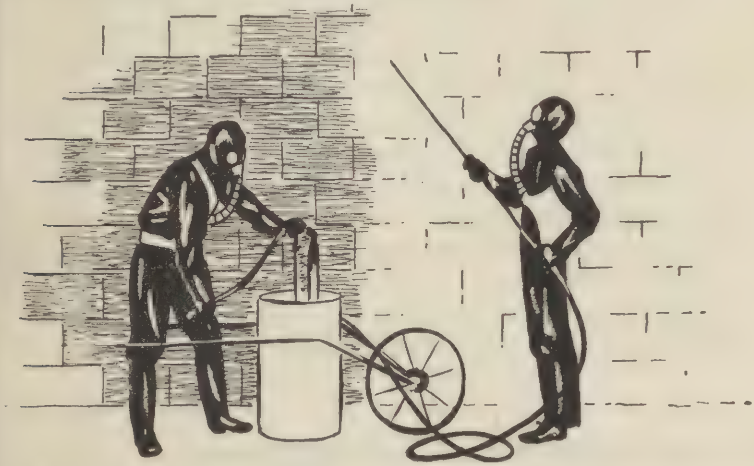


FIG. 39. Decontamination of walls.

FIG. 40. Decontamination of floors.

The windows of the building must be left open until all traces of the agent are gone. Figures 29 and 30 illustrate decontamination of walls and floors inside of buildings.

(4) *Metal equipment.*—Metal equipment should first be washed with rags containing gasoline or kerosene. These rags must be destroyed at once. Bleach solution should then be applied. This is followed by washing with soap and hot water and, finally, after thorough drying, the surface should be oiled. If the metal equipment would be seriously damaged by corrosion, the bleach should not be left on the metal for more than a few minutes. In lieu of these measures, noncorrosive decontaminating fluids, if available, may be used.

(5) *Clothing.*—A person who suspects that his clothes have come in contact with mustard vapor should remove his clothes at once and bathe. The clothes should then be aired out of doors in the sunlight for at least 2 days. If the clothes have been contaminated with liquid mustard, they should be steamed for 4 to 6 hours. A steaming unit can readily be made from a large can with a false bottom. The clothes are laid on the false bottom and the can is closed. Heat is then applied. If any odor of mustard gas remains, the clothes should be treated again.

Ordinary dry cleaning will not suffice for treating contaminated clothes. Contaminated shoes should be shuffled in sand and bleach mixture to remove unabsorbed liquid, but once the agent has penetrated the leather, little can be done to make them safe.

61. Decontamination Equipment.

In addition to protective clothing, gas masks and decontamination materials, the following items of equipment are needed in decontamination work:

a. Shovels.

b. Swabs for application of bleach.

c. Cloths.

d. Sprayer.—This may be a small hand-operated device, such as a garden sprayer, or a large, power-driven apparatus, which can be carried on a truck. For spreading bleach solution on city streets, a vehicle of the nature of a water sprinkler might be used (fig. 31).

62. Decontamination Squads.

It is probable that individual householders will have to do a certain amount of decontamination work if their homes are affected. How-

ever, it is contemplated that decontamination squads would be set up in each community to deal with major decontamination problems. They would consist of a foreman or squad leader and at least five squad members.

The foreman should be a graduate of a course of instruction similar to that of the area leader, as described in chapter VI. His job would be to supervise the work, see that equipment is kept in serviceable condition and replenished when necessary, maintain the headquarters of the squad, and train his squad members. Headquarters should be in a small garage or other such building.

The squad members should be men who are used to hard physical labor. Equipment should consist of a truck, shovels, pickaxes, crowbars, wheelbarrows, a portable spraying device, a portable hand-pump similar to that shown in figure 31, chemicals, fire hose, ¾-inch hose, several sets of protective clothes, decontaminating apparatus for the clothes, showers and dressing room for the men, and first-aid equipment.

Street-flushing trucks should be supplied by the municipal street-cleaning department for washing liquid agents off the streets. Municipal street-cleaning personnel should be trained for this work.

When a gas alarm is sounded, the squads should go immediately to their headquarters and, as soon thereafter as possible, they should report ready for work wherever their services are needed.

SECTION 5. PROTECTION OF FOOD AND WATER.

63. General Rule.

As a general precaution, food supplies, and water for drinking, cooking, or washing should be kept away from contact with chemical agents. Food having a peculiar odor or taste and suspected of having been exposed to chemical agents, should be discarded. Water suspected of such contamination should, in no circumstances, be used unless subjected to purification processes.

64. Contamination of Food.

Food may be contaminated either by direct contact with chemical agents in liquid or solid form or by exposure to the vapor. Some foodstuffs absorb gas more quickly than others. Fatty and oily substances, such as meats and butter and also meals and flour, are

rather quickly contaminated. Green vegetables are somewhat less affected by vapors.

65. Decontamination of Food.

Little has been done in the way of developing means for decontaminating food; probably, because of the obvious fact that no one method would apply in all cases. Moreover, the use of chemical means of decontamination very likely would destroy the taste of food or otherwise impair its value. Food contaminated with phosgene, chlorine or other highly volatile substances, might possibly be purified by ventilation, boiling, or other treatment with water. However, the food would probably have a disagreeable taste and be unpalatable. Food, contaminated by mustard gas, or by arsenical agents such as Lewisite and irritant smokes, could not be rendered safe to use by such means and should be discarded.

66. Protection of Food.

For protection against chemical agents, food should be kept in gastight containers or in storage rooms, sealed against penetration by gases. Canned or bottled goods exposed to gas can be used if the container is immersed in boiling water before opening. Food which is not sealed in cans or bottles should be carefully wrapped in some impervious material, such as cellophane. Ordinary paper or cloth coverings are of no use. Waxed paper gives protection against gas vapors but only limited protection against liquid chemical agents.

Warehouses for the storage of foodstuffs in bulk, such as meat and fresh vegetables, should be made gastight. In homes it is recommended that, for protection against gas attack, food be kept in original containers or gastight bottles or jars until the time of use. Refrigerators, if not gastight, should be made so by the use of rubber gaskets to seal all cracks and apertures.

Where food containers have been exposed to a gas such as mustard gas or Lewisite, prompt washing of the containers, cans, or bottles, and prompt removal of waxed paper, providing the latter are intact, should be carried out. However, precautions should be taken not to spread the gas in doing so, or to become gas casualties; and wrappers or containers carrying gas should be disposed of so as to avoid further contamination.

67. Purification of Water.

The contamination of a city's public water supply by significant amounts of toxic war gases is relatively unlikely. Some of these

gases are of low solubility in water. Others tend to dissociate in water or to react with the mineral constituents of water and form harmless end products.

The pollution of an impounding or storage reservoir on the water supply system of a large city to the degree that harmful results upon the water user could ensue would require such large quantities of the material as to suggest its improbability. On the other hand, as long as the water purification plant was functioning, its use of coagulation, sedimentation, and filtration with the attendant dosages of alum, activated carbon, ammonia, and chlorine would tend to remove the organic compounds as an incident of the modern treatment process.

So long as water is available from public supplies through regular sources, it should be assumed that the local water supply authorities, the state sanitary engineers' staffs and related Federal engineering groups would have satisfied themselves that the water delivered was safe for use. It should be also assumed that these groups would issue proper warning to the public to take steps for their own protection if the supply could not be safely used.

In case of private water supplies such as wells or cisterns, and where water is stored on premises in tanks not airtight, the water should not be used until the health authorities have indicated its safety.

CHAPTER V. PROTECTION OF ANIMALS.

68. General.

Domestic animals are affected by exposure to chemical agents in much the same way as man. Insofar as practicable, such animals should be removed from cities subject to attack and taken to rural districts.

69. Horses.

a. *Susceptibility*.—Horses and mules appear to be unaffected by tear gas, but they are affected in the same way as man by lung irritant gas, and are perhaps even more susceptible than man to injury from vesicant agents such as mustard gas. The lungs and respiratory passages of a horse are highly sensitive to lung irritant and vesicant gases.

The entire skin area of the horse is affected by vesicant gas but the most vulnerable are those tender parts where the hair is very fine or absent and where the sweat glands are most active.

The eyes do not appear to be affected by tear gases or irritant smokes but they are highly sensitive to vesicant vapors, while liquid vesicants in the eyes will cause serious injury and possibly permanent blindness.

Chemical wounds on the feet of a horse may incapacitate him. Injuries to the fetlock, coronet, the white line and the space between the bar and the frog are serious.

Inflammation of the digestive tract of a horse, with the formation of ulcers, may be caused by eating contaminated forage, grazing in a contaminated pasture or drinking from a pond in which chemical shells or bombs have exploded.

b. *First aid*.—First aid treatment for horses injured by gas is practically the same as for man. In lung injury cases, the animal should be kept warm and quiet, and removed from the gassed area by ambulance if possible. If the skin or feet have been exposed to vesicant agents, the affected parts should be treated with bleach paste for 3 minutes and then washed with soap and water for 30 minutes. Serious cases should be hospitalized.

70. Horse Masks.

A horse or mule does not breathe through the mouth, hence the horse mask need only cover the nostrils. A corrugated rubber tube connects the mask with large canisters through which the air breathed

by the horse is drawn. The canister of the horse mask purifies the air in the same manner as does the canister of the Service Mask worn by the soldier. Exhaled air passes out from the mask through a rubber outlet valve. A head strap holds the mask in position. (See fig. 32.)

71. Dogs.

Masks were provided for dogs used in foreign armies in the World War. Such masks were usually made of the same materials as the horse mask and covered the entire head of the animal. Dogs are not used in the United States Army and, hence, dog masks are not provided. Dogs subject to exposure to gas should be placed in gasproof shelters or destroyed.

72. Birds.

Lofts for homing pigeons used in the Army are made reasonably gasproof by sealing all holes except certain openings for ventilation which are stopped by means of chemically treated blankets. Pigeon containers are covered with a gasproof material to which a collective protector of small size is attached. A hand operated bellows is used to force air through a canister so that purified air is supplied to the birds in the container. Such means might be used to protect other caged birds.

O

REFERENCE AND TRAINING CHART

CHEMICAL WARFARE AGENTS

PREPARED BY OFFICE OF CIVILIAN DEFENSE

CLASS	NAMES AND SYMBOLS	FORM	ODOR	PHYSIOLOGICAL EFFECT	TACTICAL CLASS	PROTECTION	FIRST AID [After removal from gassed area]	PERSISTENCE	FIELD NEUTRALIZATION
VESICANTS	MUSTARD $S(CH_2CH_2)_2Cl_2$ DI-CHLORETHYL SULFIDE	LIQUID AND VAPOR	Garlic, Horseradish, Mustard	Delayed effect. Burns skin or membrane. Inflammation respiratory tract leading to pneumonia. Eye irritation, conjunctivitis.			Undress; remove liquid mustard with protective ointment, bleach paste, or kerosene; bathe; wash eyes and nose with soda solution.	One day to one week. Longer if dry or cold.	Cover with unslaked lime and earth. 3% solution of Na_2SO_3.
	LEWISITE $CHClCH\text{-}AsCl_2$ CHLORVINYL-DICHLORARSINE	LIQUID AND VAPOR	Geraniums	Burning or irritation of eyes, nasal passages, respiratory tract, skin: Arsenical poison.			Undress; remove liquid Lewisite with hydrogen peroxide, lye in glycerine, or kerosene; bathe; wash eyes and nose with soda. Rest—Doctor.	One day to one week. Longer if dry or cold.	Wash down with water. Cover with earth. Alcohol. NaOH spray.
	ETHYLDICHLORARSINE $C_2H_5\text{-}AsCl_2$	LIQUID AND VAPOR OR GAS	Stinging, like pepper in nose	Causes blisters, sores, paralysis of hands, vomiting. Severe on long exposure.			Undress; remove liquid with hydrogen peroxide, lye in glycerine, or kerosene; bathe; wash eyes and nose with soda. Rest—Doctor.	One hour.	Cover with earth, caustic.
LUNG IRRITANTS	CHLORINE Cl_2	GAS	Highly Pungent	Lung irritant.			Remove from gassed area. Keep quiet and warm. Coffee as stimulant.	10 minutes.	Alkaline solution.
	CHLORPICRIN CCl_3NO_2 NITROCHLOROFORM	GAS	Flypaper, anise	Causes severe coughing, crying, vomiting.			Wash eyes, keep quiet and warm. Do not use bandages.	Open 6 hours. Woods 12 hours.	$NaSO_3$—Sodium sulfite in alcohol solution.
	DIPHOSGENE $ClCOOC\text{-}Cl_3$ TRICHLORMETHYL CHLOROFORMATE	GAS	Ensilage, Acrid	Causes coughing, breathing hurts, eyes water, toxic.			Keep quiet and warm. Give coffee as a stimulant.	30 minutes.	Alkali.
	PHOSGENE $COCl_2$ CARBONYL CHLORIDE	GAS	Musty hay, Green corn	Irritation of lungs, occasional vomiting, tears in eyes, doped feeling. Occasionally symptoms delayed. Later, collapse, heart failure.			Keep quiet and warm, bed rest. Coffee as a stimulant. Loosen clothing. No alcohol or cigarettes.	10 to 30 minutes.	Alkali.
LACRIMATORS	CLORACETOPHENONE $C_6H_5CO\text{-}CH_2Cl$	GAS	Apple Blossoms	Makes eyes smart. Shut tightly. Tears flow. Temporary.			Wash eyes with cold water or boric acid solution. Do not bandage. Face wind. For skin, sodium sulphite solution.	10 minutes.	Strong, hot solution of sodium carbonate.
	BROMBENZYLCYANIDE $C_6H_5CH\text{-}BrCN$	GAS	Sour fruit	Eyes smart, shut, tears flow. Effect lasts some time. Headache.			Wash eyes with boric acid. Do not bandage.	Several days. (Weeks in winter.)	Alcoholic sodium hydroxide spray.
STERNUTATORS	ADAMSITE $(C_2H_4)_2\text{-}NHAsCl$ DIPHENYLAMINECHLORARSINE	GAS	Coal Smoke	Causes sneezing, sick depressed feeling, headache.			Keep quiet and warm. Loosen clothing. Reassure. Spray nose with neo-synephrin or sniff bleaching powder. Aspirin for headache.	10 minutes.	Bleaching powder solution.
	DIPHENYLCHLORARSINE $(C_6H_5)_2\text{-}AsCl$	SMOKE	Shoe Polish	Causes sick feeling and headache.			Remove to pure air, keep quiet. Sniff chlorine from bleaching powder bottle.	Summer 10 minutes.	Bleaching powder solution.
SMOKES	H C MIXTURE $ZN + C_2Cl_6$	SMOKE	Sharp-Acrid	Harmless.		None needed.	Produces no effect requiring treatment.	While burning.	None needed.
	SULPHUR TRIOXIDE $SO_3 + SO_3HCl$ IN CHLORSULFONIC ACID	SMOKE	Burning matches	Causes prickling of skin, flow of tears.			Wash with soda solution.	5 to 10 minutes.	Alkaline solution.
	TITANIUMTETRACHLORIDE $TiCl_4$	SMOKE	Acrid	Harmless.		None needed.	Produces no effect requiring treatment.	10 minutes.	None needed.
INCENDIARIES	WHITE PHOSPHORUS P	SMOKE	Burning matches	Burning pieces adhere to skin, clothing.		None needed.	Pack in cloths wet with copper sulphate (blue vitriol) or water or immerse in water. Pick or squeeze out particles. Treat for burn.	10 minutes.	Burns out.
	THERMIT $8Al + 3FeO_4$	INCENDIARY	None	5,000 degree heat ignites materials.		None needed.	Treat for severe burn.	5 minutes.	Quickly cover with earth or sand.

GENERAL INSTRUCTIONS

The importance of proper first aid for gas victims cannot be overemphasized. The following are general rules which apply in all cases.

A. Act promptly and quietly; be calm.

B. Put a gas mask on the patient if gas is still present or, if he has a mask on, check to see that his is properly adjusted. If a mask is not available, wet a handkerchief or other cloth and have him breathe through it.

C. Keep the patient at absolute rest; loosen clothing to facilitate breathing.

D. Remove the patient to a gas-free place as soon as possible.

E. Summon medical aid promptly; if possible, send the victim to a hospital.

F. Do not permit the patient to smoke, as this causes coughing and, hence, exertion.

KEY

HOSPITAL CASE

FIRST AID TREATMENT

SMOKE

INCENDIARY

MASK PROTECTION NEEDED

FULL PROTECTIVE CLOTHING NEEDED